AD NUMBER

AD824972

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 20 OCT 1967. Other requests shall be referred to Space and Missile Systems Organization, Norton AFB, CA.

AUTHORITY

SAMSO ltr, 28 Feb 1972

REPORT NO. GDC ANR 67-005

AD824972

NIKE ABRES OAR

OV1

ATLAS E/F BOOSTERS AND ABRES-A CRITERIA FOR PAYLOAD DESIGNERS

[redacted]

GENERAL DYNAMICS
Convair Division

REPORT NO. GDC-ANR67-005

ATLAS E/F BOOSTERS AND ABRES-A CRITERIA FOR PAYLOAD DESIGNERS

20 October 1967

Prepared for
Space and Missile Systems Organization (SAMSO)
Air Force Systems Command
United States Air Force

Prepared by
CONVAIR DIVISION OF GENERAL DYNAMICS
San Diego, California

This document is subject
to special export controls and
each transmittal to foreign
governments or foreign
nationals may be made only
with prior approval of:
Hq.SAMSO, LA., Ca. 90045
Attn: SMSD

APPROVALS

The contents of this document are approved for the use and guidance of all concerned.

Approved by: C. J. Dunn

C. J. Dunn
Director
BMRS Program Integration

E. J. Brechwald

Col. E. J. Brechwald
Space and Missile Systems Organization/SMVZO-1
Norton Air Force Base, California

Morton Goldman

M. Goldman
Aerospace Corporation
San Bernardino, California

FOREWORD

A total of 135 E/F Atlas boosters, originally delivered to the USAF in support of the national defense system, have now been assigned to support the Ballistic Missile Re-entry Systems (BMRS) program. These boosters are currently programmed for refurbishment and modification to support specific payloads designated by the Air Force.

This document contains generalized performance capabilities of E/F Atlas boosters when launched from the ABRES-A launch sites and provides interface data required by Payload Contractors in the design of their respective payloads. Each Payload Contractor is required to make maximum use of existing E/F boosters and ABRES launch site capabilities. Additional capabilities will be provided only upon justification of requirements and subsequent approval by the Space and Missile Systems Organization (SAMSO), BMRS Full Scale Launch Program Office (SMVZO). The roles and responsibilities delegated by SMVZO to BMRS program participants are described in detail in Convair Report GDC-BGJ67-008, BMRS Full Scale Launch Program Plan.

The data contained herein supersedes and replaces previous data contained in Convair Report GDC-ANR65-007.

CONTENTS

CONTENTS (CONT.)

SECTION 1
ATLAS E/F BOOSTER PERFORMANCE CAPABILITY

This section presents, in a generalized format, the performance capability of Atlas E/F boosters. The data was generated for specific missile configurations and for specific mission requirements. Therefore, the data included is not to be used for detailed planning purposes; it is intended to enable payload contractors and potential users of Atlas E/F boosters to make preliminary estimates of the ranges, reentry angles, reentry velocities, and trajectory accuracies that are achievable with a given configuration to a given target area.

The impact area selected for a specific mission is usually determined by program requirements and the availability of downrange sensors. The reentry flight path angle (gamma), at a reentry altitude of 300,000 feet, selected for a specific mission is usually determined by program requirements and booster payload capability. Once these two variables are selected, all other trajectory parameters are fixed and are a function of missile lift-off weight, payload, guidance system, etc. Mission peculiar trajectory data, payload capability, reentry velocity, inertial attitude at separation, etc., will not be available until the mission has been targeted and a flight test trajectory generated to support the mission.

This section presents parametric data, in the form of curves showing the dependence of achievable trajectory parameters and payload weights for Atlas E/F boosters launched from Vandenberg Air Force Base. The data presented was obtained from results of trajectory studies performed by Convair using the COMBO trajectory simulation program. The trajectory simulations were not bounded by the Atlas E/F booster constraints; i.e., aeroheating, control dynamics, structural dynamics, etc. Therefore, when mission peculiar characteristics are factored into the trajectory simulations, i.e., trajectory requirements, payload shape and size, payload bending moments, etc., somewhat different trajectory parameters may result. Therefore, the data presented is to be used for general mission planning only and is not to be applied in detailed mission analyses.

1.1 DEFINITIONS

Pitch Attenuation Factor (PAF). A multiplication factor applied to the Atlas pitch programmer output during booster phase of flight. In general, a PAF < 1 implies a lofted trajectory, and a PAF ≥ 1 implies a depressed trajectory. A PAF of 0.97 was the nominal setting of the operational fleet. The PAF is a function of mission requirements and is determined in the targeting process.

Sustainer Pitch Resolver Null Setting (PRNA). On inertially guided missiles the pitch steering philosophy is such that the missile roll axis is maintained at a constant inertial

angle with respect to the launch vertical. A PRNA of 70 degrees was the nominal setting of the operational fleet. The PRNA is a function of mission requirements and is determined in the targeting process.

Propellant Residuals. Propellant residuals are defined as the remaining sustainer engine burnable propellants at the time of sustainer engine cutoff (SECO). Based on past history, with a PAF of 0.97, a PRNA of 70 degrees, and a range of 5000 nautical miles, a nominal propellant residual of 880 pounds is required to ensure a 97 percent probability of mission success at a 90 percent confidence level. The probability and confidence levels change as trajectory characteristics change.

Payload. Payload is defined as all equipment which is attached to the basic booster. This includes all equipment above the reentry vehicle interface point (either Station 502 or 540.55) including spacers, adapters, HIRS units, ballast, etc. This also includes any sidemounted equipment weights, mounting hardware, payload ejection modules, shrouds, payload, etc. The increased payload weight capability of radio-guided Atlas boosters over inertially-guided boosters is due to the removal of Arma inertial guidance system components.

Reentry Angle (Gamma). The angle at which the flight path angle of the reentry vehicle intersects the local geodetic horizontal plane at reentry altitude. Reentry altitude is assumed to be 300,000 feet unless otherwise specified. Gamma is determined by PAF and PRNA on inertially guided boosters. Gamma will vary with range with a fixed PAF and PRNA.

1.2 GENERAL PERFORMANCE CAPABILITY. Figure 1-1 shows the approximate range-payload capability of the Atlas E/F booster with inertial guidance launched from the Air Force Western Test Range (AFWTR). The ordinate also includes an estimate of the increased payload capability with RIG. The curve shown is based on the following assumptions:

a. Non-Rotating Earth (Polar Launch Capability).

b. A PAF of 0.97 and a PRNA of 70 degrees.

c. Propellant residuals of 880 pounds.

Figure 1-2 shows the approximate range capability loss versus payload weight as the initial launch azimuth varies from a polar launch azimuth towards the west. The range capability loss is due to the effects of a rotating Earth.

Figure 1-3 shows the approximate payload capability of the Atlas E/F boosters with reentry angle (gamma) and range as independent variables. The various gammas were achieved by varying PAF and PRNA.

NOTES:
1. 0.97 PITCH ATTENUATION FACTOR (PAF)
2. PROPELLANT RESIDUALS OF 380 LB
3. AFWTR POLAR LAUNCH (NON-ROTATING EARTH)
4. PITCH RESOLVER NULL ANGLE 70 DEG

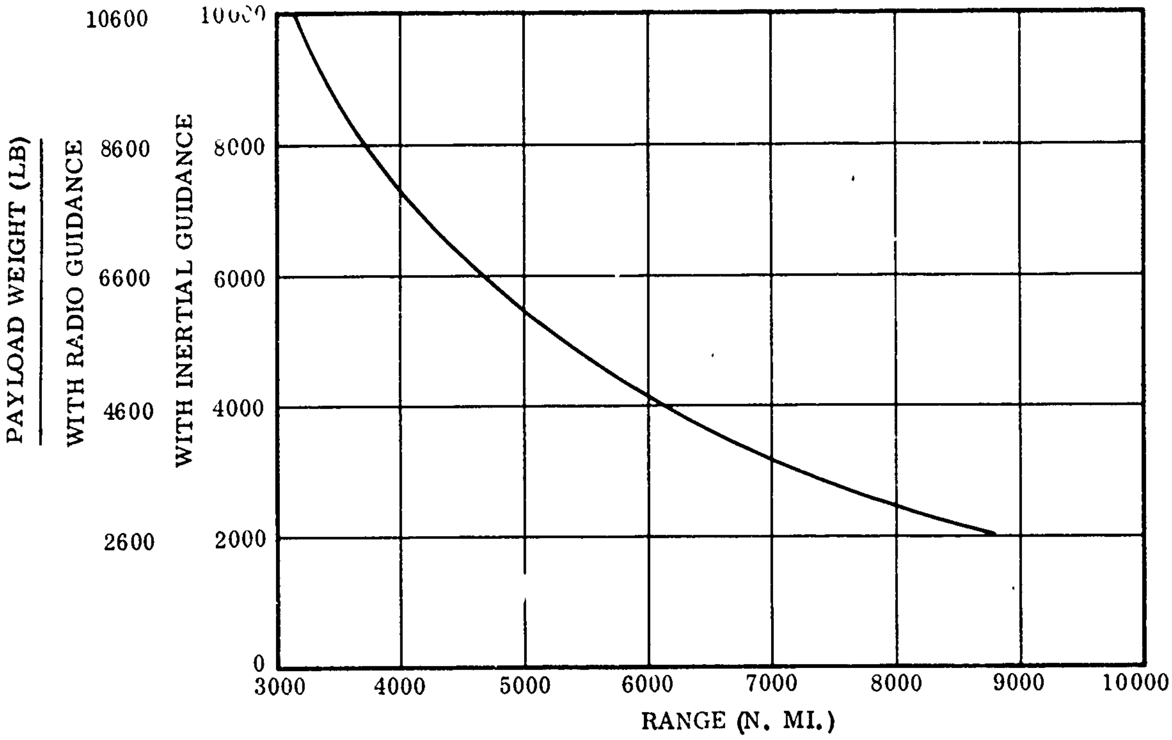


Figure 1-1. Payload vs. Range, Atlas F Booster Launched From AFWTR, Non-Rotating Earth, Polar Launch

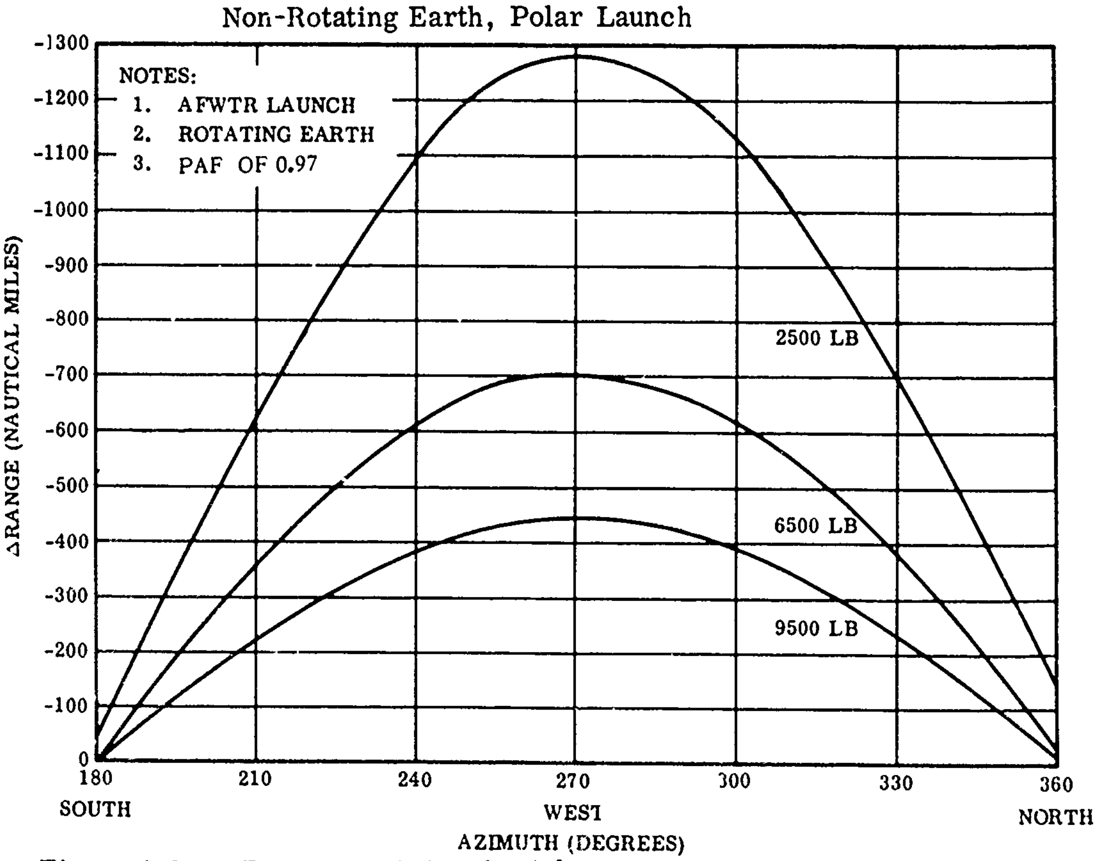


Figure 1-2. ΔRange vs. Azimuth, Atlas F Booster Launches From AFWTR

NOTES:
1. AFWTR LAUNCH
2. 270° LAUNCH AZIMUTH (WEST)
3. ROTATING EARTH
4. GROSS LAUNCH WT = 263,321 LB + PAYLOAD (ABOVE STATION 502)
5. RESIDUALS OF 880 LB
6. VARIABLE PAF

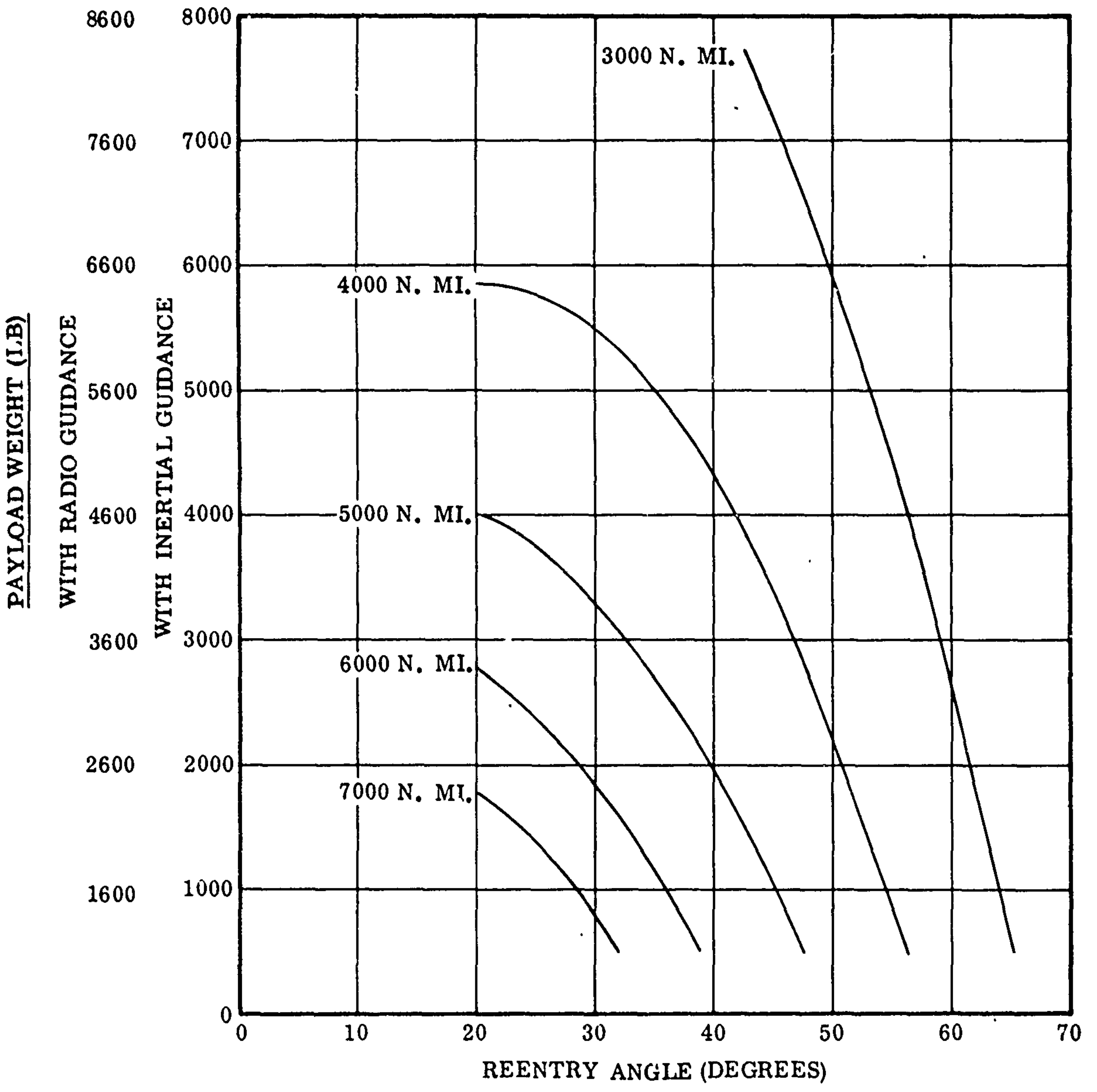


Figure 1-3. Payload vs. Re-entry Angle, Atlas E/F Booster

1.3 POLAR ORBIT CAPABILITY. Questions continually arise as to the capability of the Atlas E/F booster to boost a payload directly into a low circular orbit even though a north polar launch is politically prohibited and a south polar launch is restricted due to range safety hazards during early booster phase. At present, the AFWTR limits ABRES-A launches to a maximum southerly launch azimuth of 225.5 degrees from north. Launched on this launch azimuth, the Atlas E/F booster has no significant direct ascent to polar orbit payload capability.

Figure 1-4 is included as an academic exercise to satisfy the curiosity of the Atlas direct-polar orbit capability. The data were taken from a polar launch open-loop trajectory simulation, using various PAFs and constant sustainer pitch rates from BECO +5 seconds to SECO to achieve the desired orbital altitudes.

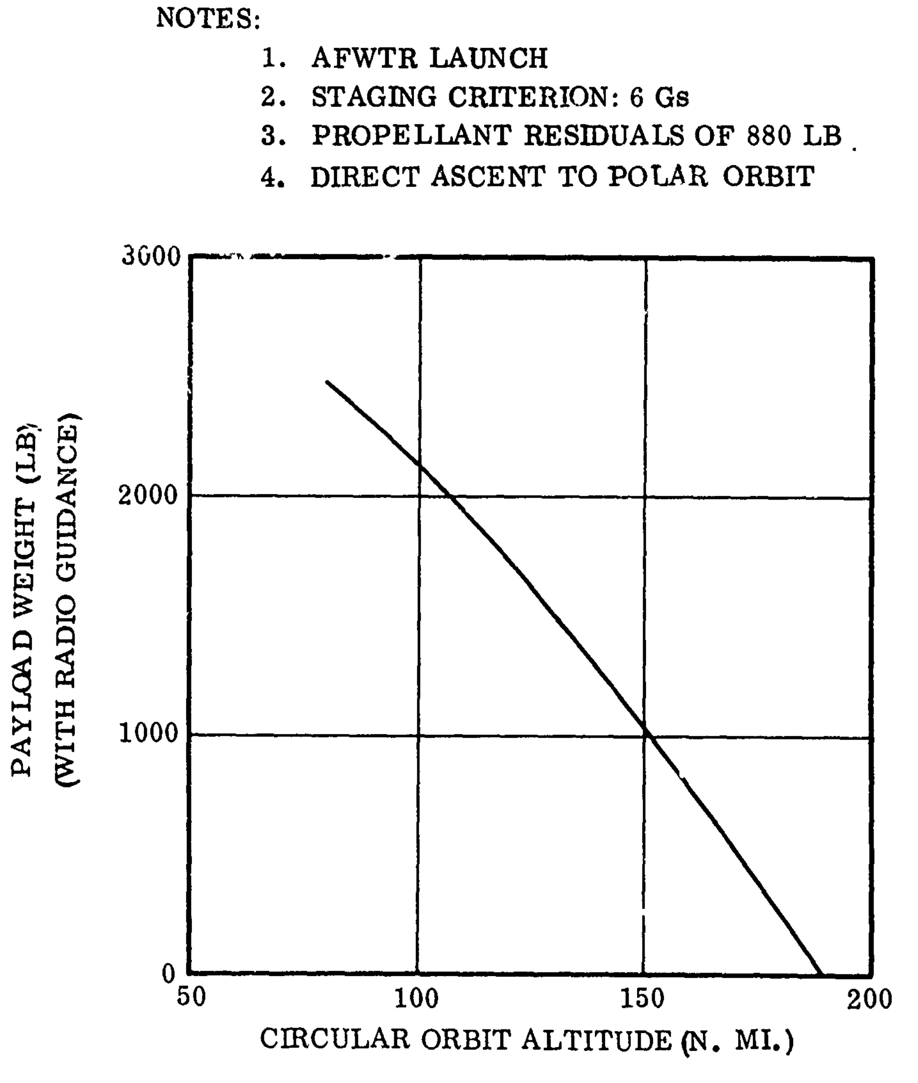


Figure 1-4. Atlas E/F Booster Polar Capability (AFWTR Launch)

1.4 CAPABILITY CURVES FOR SELECTED TARGET AREAS. A comprehensive performance evaluation of the Atlas E/F booster launched from AFWTR to target areas near Kwajalein Atoll (4200 n.mi.), Hawaiian Islands (2065 n.mi.), Johnston Island (2823 n.mi.), and Woomera, Australia (7400 n.mi.) is presented in Figures 1-5 through 1-10. These data were obtained from closed-loop trajectory simulations in which the Arma AIG system was used to command booster, sustainer, and vernier engine cutoff signals and to steer the booster during the sustainer phase so as to impact at the desired target. The PRNA during sustainer phase was essentially the same as the attitude at the end of the booster phase.

A constant aerodynamic drag coefficient (C_D = 7.6) was used in the reentry portions of the trajectories. Reentry occurs at 400,000 feet.

Payload weight includes the reentry vehicle weight, a 180 pound spacer, and a 575 pound High Impulse Retrorocket System (HIRS) adapter. The gross launch weight was 263,321 pounds plus payload weight (i.e., AIG configuration). The payload capability depicted in Figures 1-5 through 1-10 can be increased by 600 pounds for Atlas E/F boosters equipped with radio guidance (RIG) system due to the weight difference between the AIG and RIG configurations.

1.5 TRAJECTORY PARAMETER ACCURACY

1.5.1 Arma All Inertial Guidance (AIG). The Arma AIG airborne system consists of an inertial platform package, an electronics and control package, a computer package, and a telemetry system. Pitch attitude of the booster during sustainer phase is controlled by the pitch resolver in the Arma platform, preset to inertial angle (PRNA). Accelerometers in the platform feed information to the Arma computer. BECO is transmitted when the downrange velocity exceeds a preset constant. Yaw steering during sustainer and vernier phases and the SECO and VECO discrete commands are computed using implicit-type guidance equations designed to minimize target miss. Due to the pitch steering philosophy of this system, dispersions in the booster phase pitch program translate directly into gamma and pitch angle-of-attack dispersions at separation, as well as altitude and velocity dispersions. However, the positional errors at target impact are minimized.

1.5.2 General Electric Mod III Radio Guidance System. The radio guidance system is composed of an airborne subsystem and a ground subsystem.

The airborne subsystem is composed of a rate subsystem transponder, a track subsystem transponder, waveguide, diplexer, antenna, and a decoder for interpreting commands and conditioning them for transfer to the booster autopilot system.

The ground subsystem of the General Electric Radio Tracking System (GERTS) is composed of a track radar subsystem, a rate radar subsystem, and interface equipment to utilize an IBM 7094 computer system as a ground computer. The guidance program and

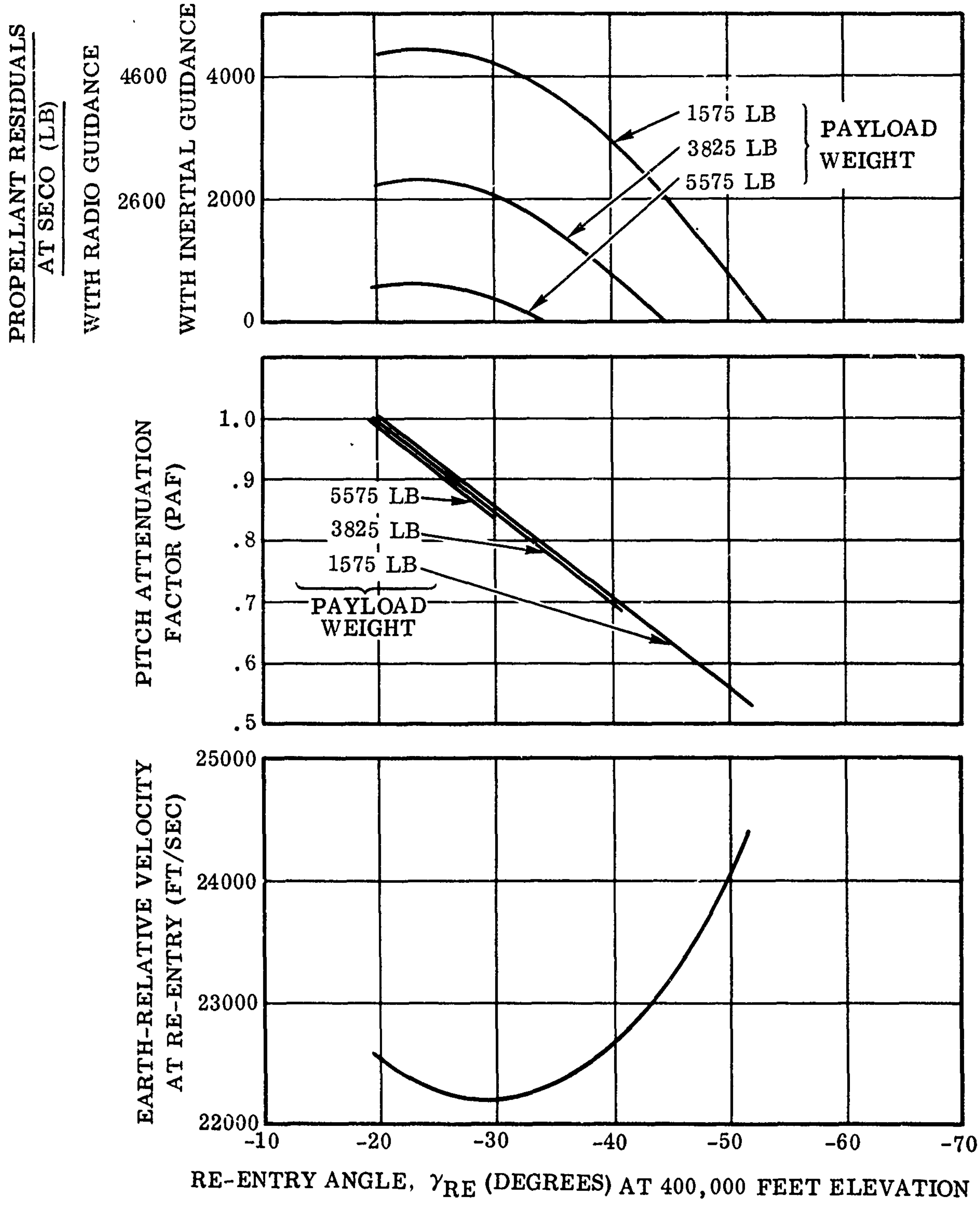


Figure 1-5. Propellant Residuals, PAF, and Earth Relative Velocity vs. Re-entry Angle, Kwajalein Target

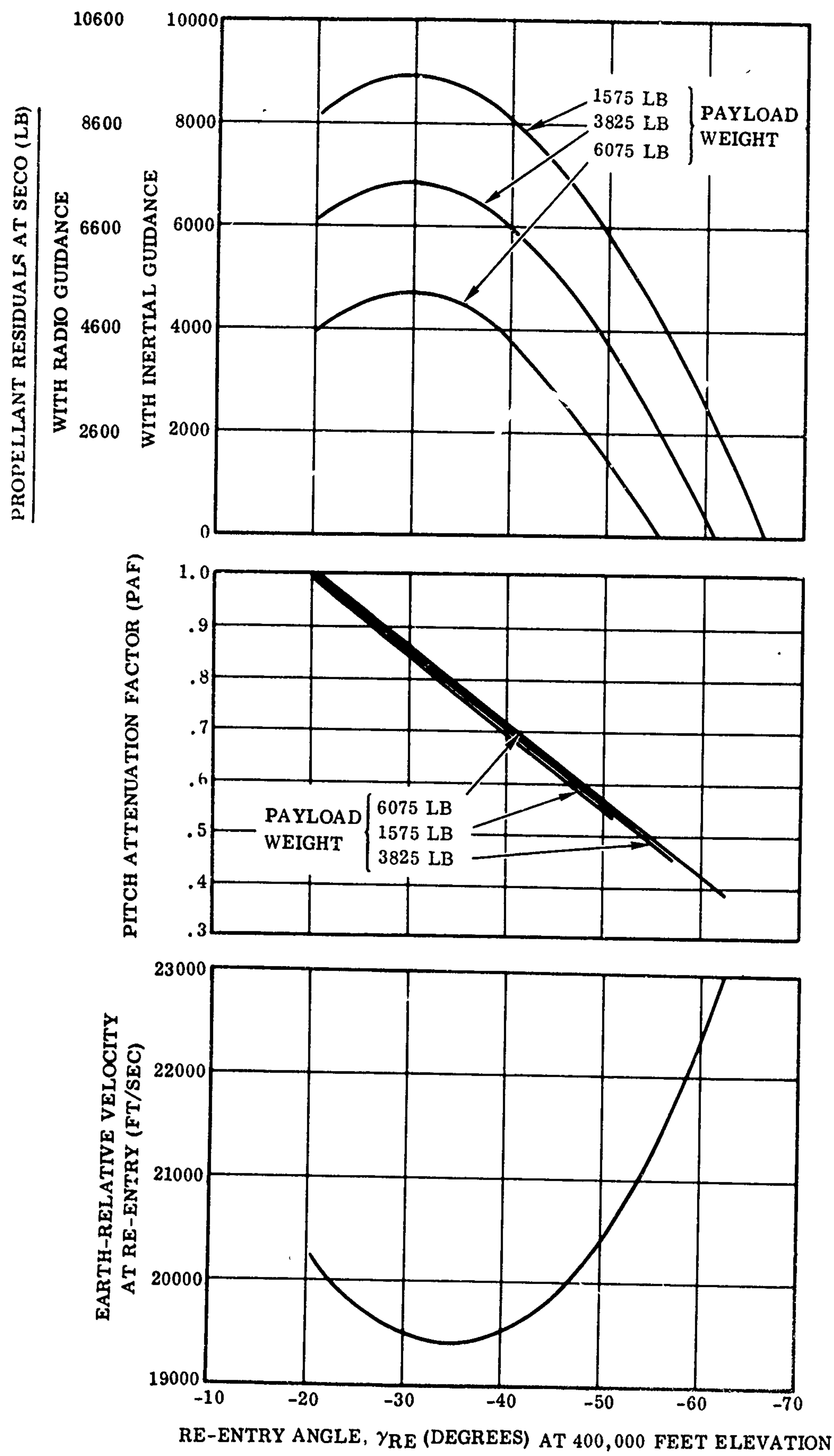


Figure 1-6. Propellant Residuals, PAF, and Earth Relative Velocity vs. Re-entry Angle, Johnston Island Target

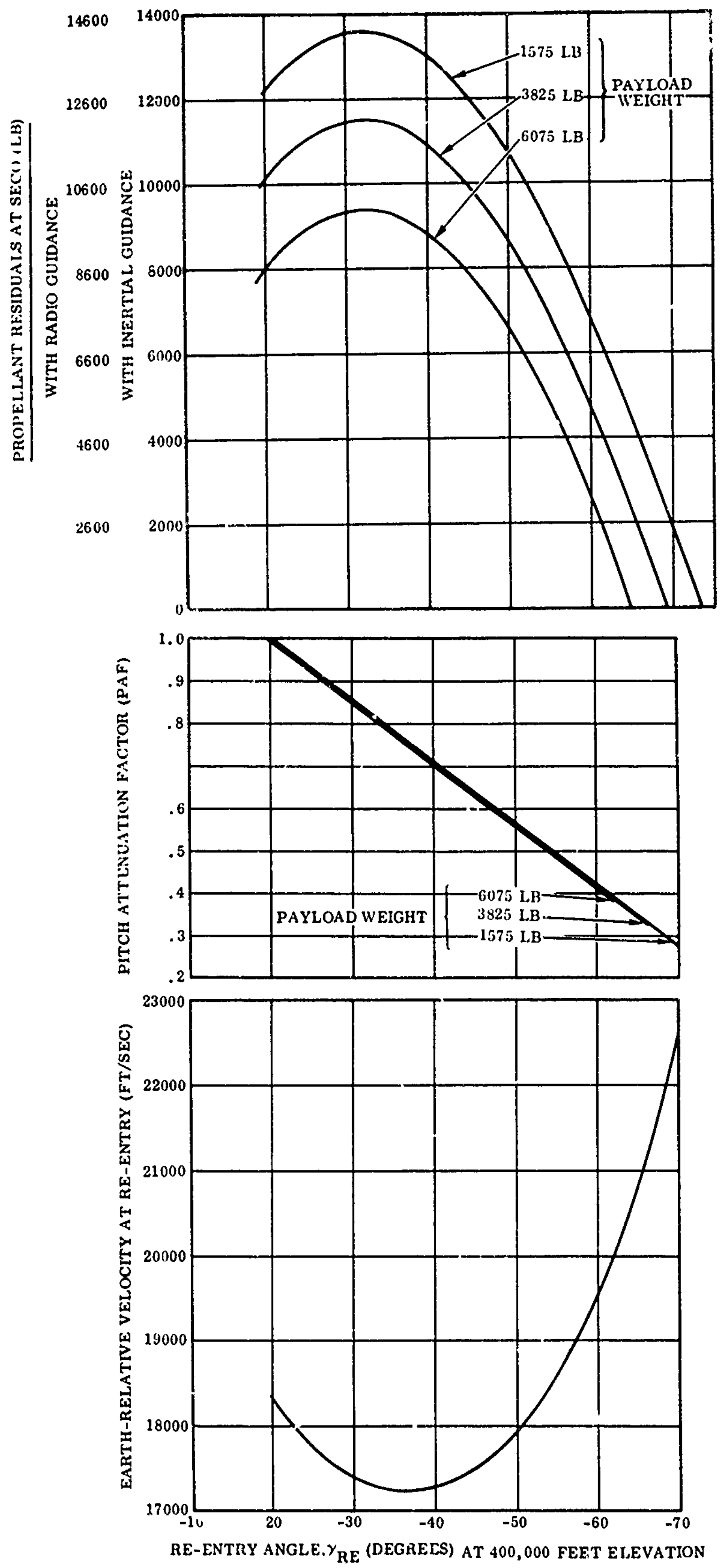


Figure 1-7. Propellant Residuals, PAF, and Earth Relative Velocity vs. Re-entry Angle, Hawaii Target

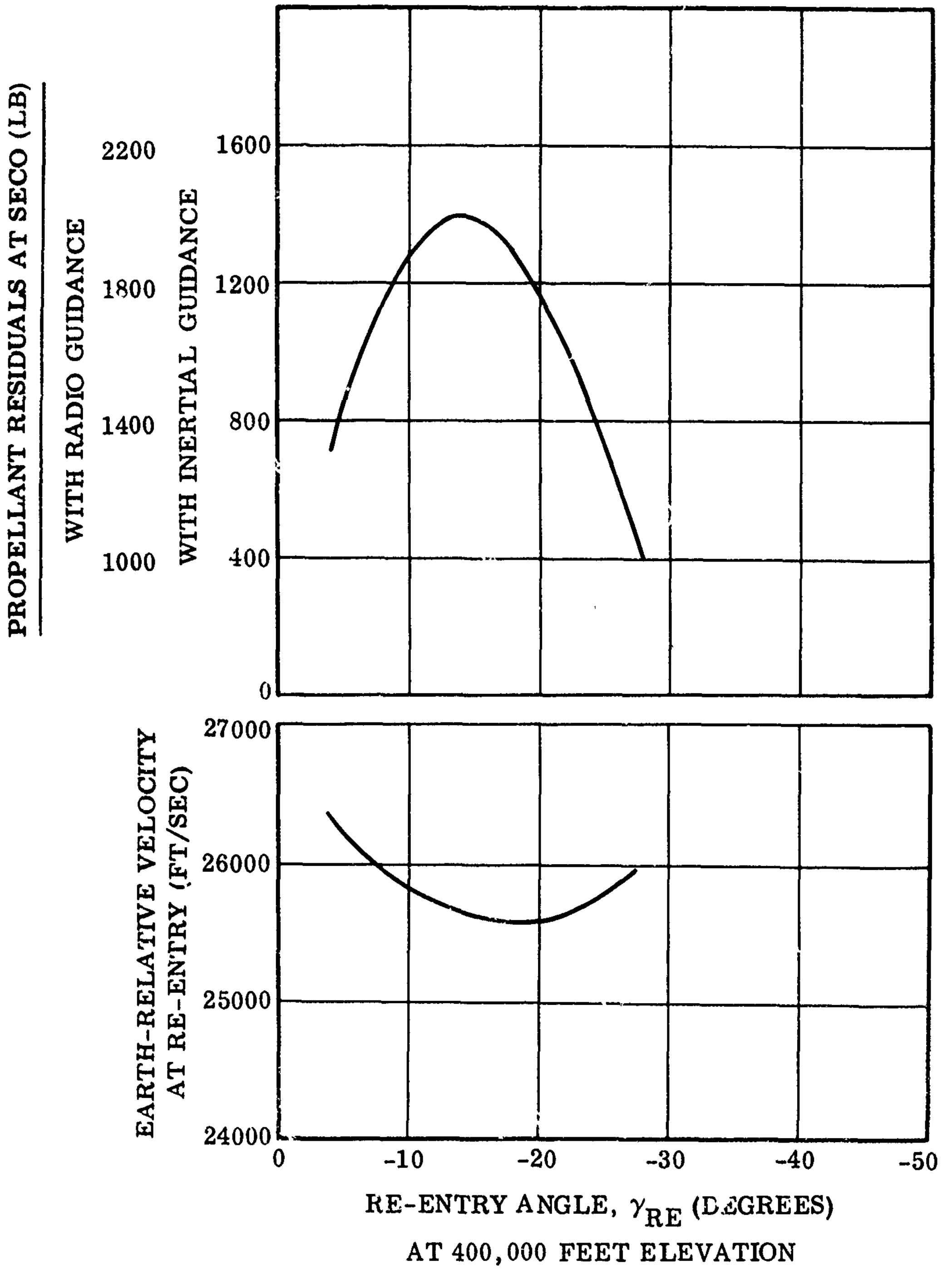


Figure 1-8. Propellant Residuals and Re-entry Velocity vs. Re-entry Angle, Woomera Target

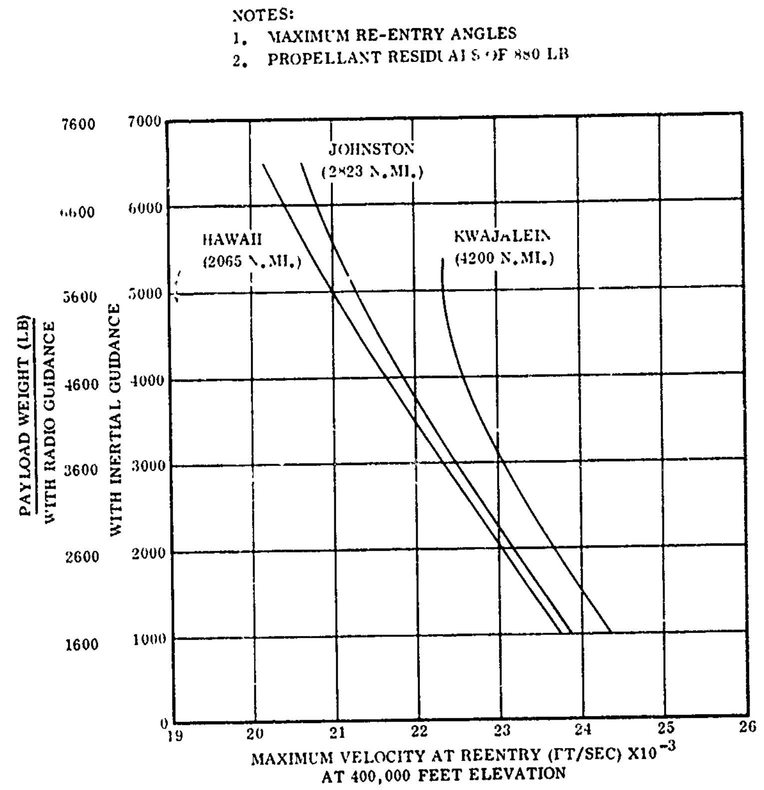


Figure 1-9. Maximum Payload and Re-entry Velocity For Kwajalein, Johnston, and Hawaii Targets

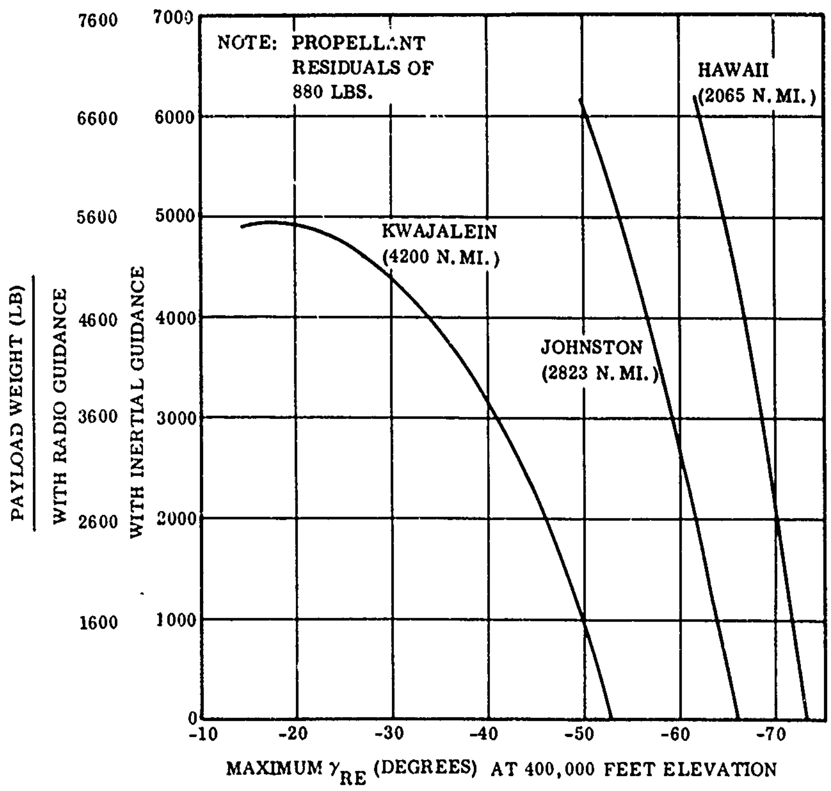


Figure 1-10. Maximum Payload and Re-entry Angles For Kwajalein, Johnston, and Hawaii Targets

and an explicit set of guidance equations are contained in the IBM 7094 computer. The RMP-B guidance equations presently utilized in the computer are designed to minimize dispersions in reentry angle and attitude at separation with some compromise in impact accuracy at the target.

1.5.3 Table 1-1 lists expected trajectory parameter dispersions for the two guidance systems. These data are listed for information purposes only. The expected dispersions for a given mission will depend upon mission requirements and mission configuration.

Table 1-1. Summary of Expected Trajectory Parameter Dispersions for Kwajalein Target Area

EVENT	AIG SYSTEM	RIG SYSTEM
Separation		
Time	± 9.85 Seconds	± 2.6 Seconds
Gamma	± 2.5 Degrees	± 0.1 Degree
Attitude Pitch	± 0.5 Degree *	± 1.0 Degree
Attitude Yaw	± 1.0 Degree	± 1.0 Degree
Reentry		
Time	± 60 Seconds	± 5 Seconds
Gamma	± 2.5 Degrees	± 0.1 Degree
Velocity	± 130 Ft/Second	± 10 Ft/Second

*With respect to Launch Astronomic Vertical

SECTION 2
AIRBORNE MECHANICAL CRITERIA

Designs for new payloads should incorporate the capability for mechanical interface with available or already-designed payload mating adapters for the ABRES/NIKE Atlas E/F basline boosters. This section summarizes the primary characteristics of available payload mating adapters, mechanical interface dimensions, and related auxiliary items.

Available designs for payload adapters provide adapter payload interface planes in diameters of 32, 48, 60, and 84 inches. Detailed drawings of mechanical interfaces can be provided upon request.

The 48-inch diameter can be used either with or without the High Impulse Retrorocket System (HIRS). Auxiliary payloads, such as decoys, scientific experiments, and satellites can be carried simultaneously to augment a particular mission. Capabilities for carrying these auxiliary payloads are defined in this section. Typical mechanical interfaces and available adapters are discussed in the following subsections.

Drawings of bolt circle layouts and drill plates for the four interface diameters are available. Before detail design is begun, it is essential that a payload mechanical interface drawing be negotiated and agreed upon by all interested parties. The information provided here will facilitate selection prior to formal interface drawing agreements.

Provision to mount a separation switch is required at the booster/payload separation plane.

2.1 ATLAS E/F BOOSTER CONFIGURATION. The basic E/F booster mechanical configuration is shown in Figure 2-1. This is a typical layout which shows a HIRS adapter installed, showing the mechanical interface at booster station 415.

2.2 PAYLOAD ADAPTERS. Numerous payload adapters have been designed for various payloads. The adapter/payload interface diameters range from 32 to 84 inches. Existing designs are shown in Figure 2-2.

Mechanical details for each adapter interface plane are shown, with the exception of the 60-inch PRIME adapter, which can be modified to specific requirements. The booster tank interface (station 502), forward bulkhead configuration, and side-mounted payload interfaces are also included.

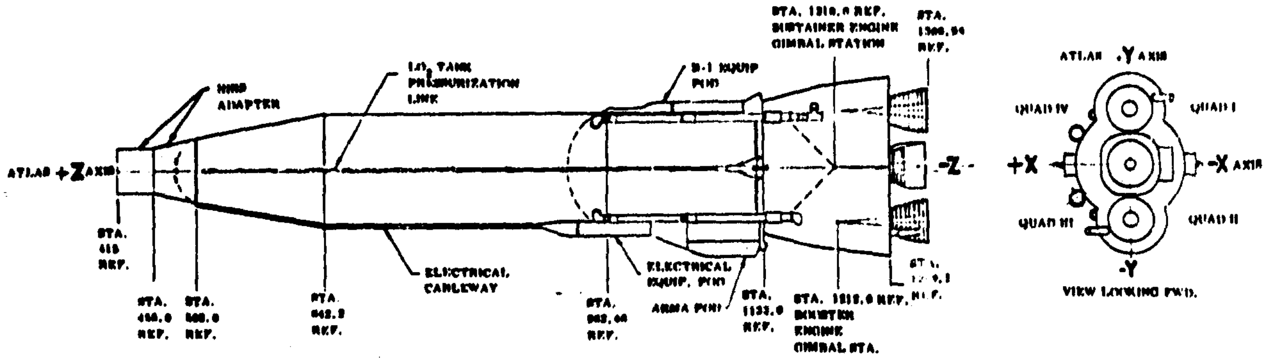


Figure 2-1. Atlas E/F Baseline Booster Configuration

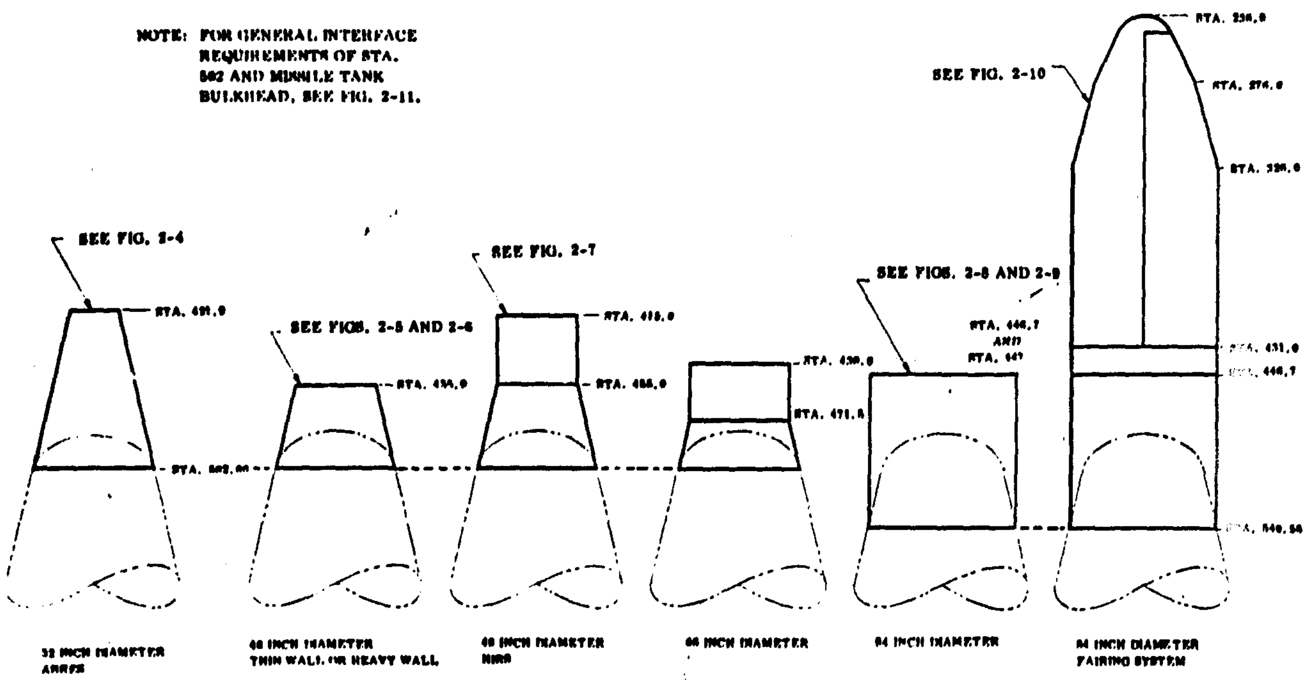


Figure 2-2. Payload Adapters

2.2.1 Internal Pressure Limits, HIRS and Standard 13.5-Degree Conical Adapters. The internal pressure limits for the HIRS and standard 13.5-degree conical adapters are shown in Figure 2-3. This data shows the limits of the pressure environment the payload manufacturer can expect in these adapters, subject to the provision that the payload or spacer venting does not materially affect the adapter internal pressure.

2.2.2 Payload and Spacer Venting Criteria. Adapter internal pressure will not be affected if

a. The spacer (structure immediately forward of the adapter) is internally sealed from the adapter, or

b. The payload and spacer are not vented externally but vent exclusively into the adapter, or

c. The payload and spacer have external vents and also vent internally to the adapter, but the payload/spacer external vents cause pressures within the adapter limits.

Item c. is met in general if the payload/spacer vent area is small compared to the adapter vent area. These adapters are typically vented* with approximately twenty holes, circumferentially spaced, with total area of 25 in.^{2}

The data presented in Figure 2-3 represents a composite of analytical studies and flight tests results. A typical internal pressure history would vary with Mach number similar to the upper limit curve, although the peak value could be significantly less than shown. However, enough variables and uncertainties exist to make the given limit values reasonable design conditions to meet at all flight times.

2.2.3 Payload Spacer Barriers. Payloads that utilize hydrocarbon fluids may require a sealed barrier to protect the booster forward bulkhead.

2.3 MECHANICAL INTERFACE. Mechanical-interface designs that are currently available are described in paragraphs 2.3.1 through 2.3.4.

2.3.1 Payload Adapter Mechanical Interface, 32-inch Diameter. The booster/payload interface plane for the 32-inch diameter adapter is located at booster station 421.9; the interface is shown in Figure 2-4.

---

*The vent configuration varies somewhat with particular versions of these adapters

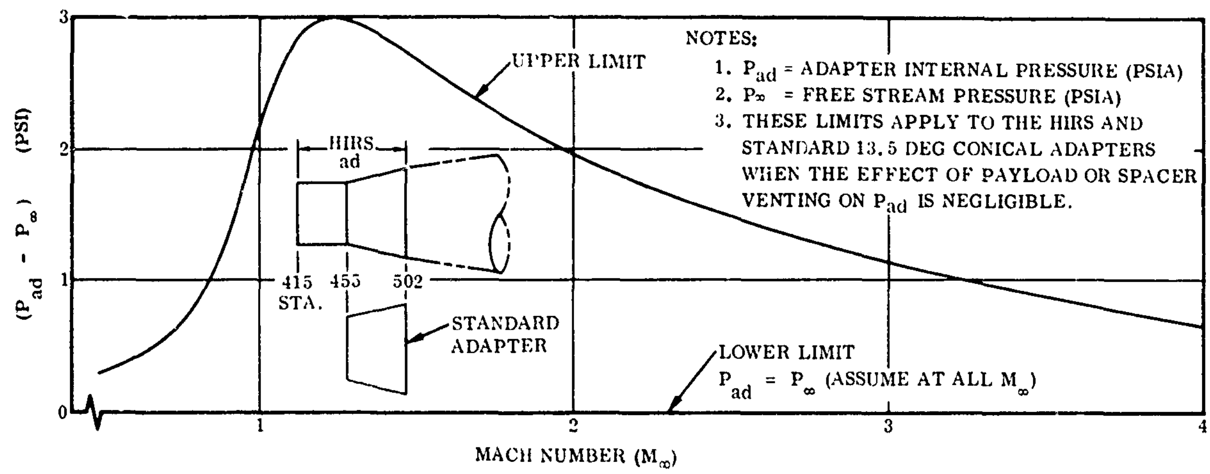


Figure 2-3. Relative Internal Pressure Limits, HIRS and Standard 13.5-Degree Conical Adapter

2.3.2 Payload Adapter Mechanical Interface, 48-Inch Diameter. The following 48-inch adapters are available:

a. E/F Operational, Interface Plane at Station 455 (Figure 2-5).

b. HIRS Tapered, Interface Plane at Station 455 (Figure 2-5).

c. Dual OV1, Interface Plane at Station 455 (Figure 2-6).

d. HIRS Cylindrical, Interface Plane at Station 415 (Figure 2-7).

2.3.3 Payload Adapter Mechanical Interface, 84-inch Diameter. Two 84-inch diameter interfaces, as shown in Figures 2-8 and 2-9 are available. The interface shown in Figure 2-8 is utilized with the fairing system shown in Figure 2-10. Separation of the payload occurs at the interface plane, station 447.00, for the interface shown in Figure 2-9. For both of these adapters, a ring has to be welded at booster station 549.

2.3.4 Payload Adapter Mechanical Interface, 70-inch Diameter. Figure 2-11 shows the mechanical interface and clearances required at booster station 502 for the 70-inch diameter interface. This is the normal attachment point to the booster tank section. A payload adapter can be attached at this point.

2.4 FAIRING SYSTEM, 84-INCH DIAMETER. Figure 2-10 describes a fairing system originally designed for OV1 satellites. A spacer module is attached to the mechanical interface shown in Figure 2-8. Four truss beams are installed in the forward end of the spacer to support the spacecraft mounting structure.

The nose fairing is a double cone cylinder with a hemispherical cap. It is fabricated from welded skins riveted to sheet-metal internal frames. No longitudinal stiffeners are required.

The cylindrical section is 105 inches long and can be increased to 150 inches or reduced to any practical length. The weight of 3.5 pounds per inch may be used in estimating weight changes due to lengthening or shortening of the fairing. Total weight of the fairing system/adapter is approximately 1,100 pounds.

Fairing jettison may be programmed as desired, provided that booster acceleration is less than 2.5 g's.

2.5 PAYLOAD EJECTION MECHANISMS (PEM). Figures 2-12, 2-13, and 2-14 show the general arrangement for installation of the MOD I, MOD II, and MOD IV PEMs.

The booster baseline provides for installation of MOD I or MOD II PEMs in Quads I and III, centered at 21 degrees from the X-X axis.

PEM IV may be attached in Quad I and/or Quad III by means of weld-on and bolt-on kits.

Convair document GDC-BJS67-003, Atlas Booster/PEM Interface Control Document, contains PEM's interface details.

2.6 AUXILIARY PAYLOADS, SIDE MOUNTED. Figures 2-15 and 2-16 depict the general arrangement and location for Scientific Passenger Pods (SPP) and CV1 pods. The tank weldments are designed to support a 700-pound SPP or a 1400-pound OV1 pod.

Auxiliary payloads must be considered during analyses of the prime mission, since they affect performance, dynamics, and targeting.

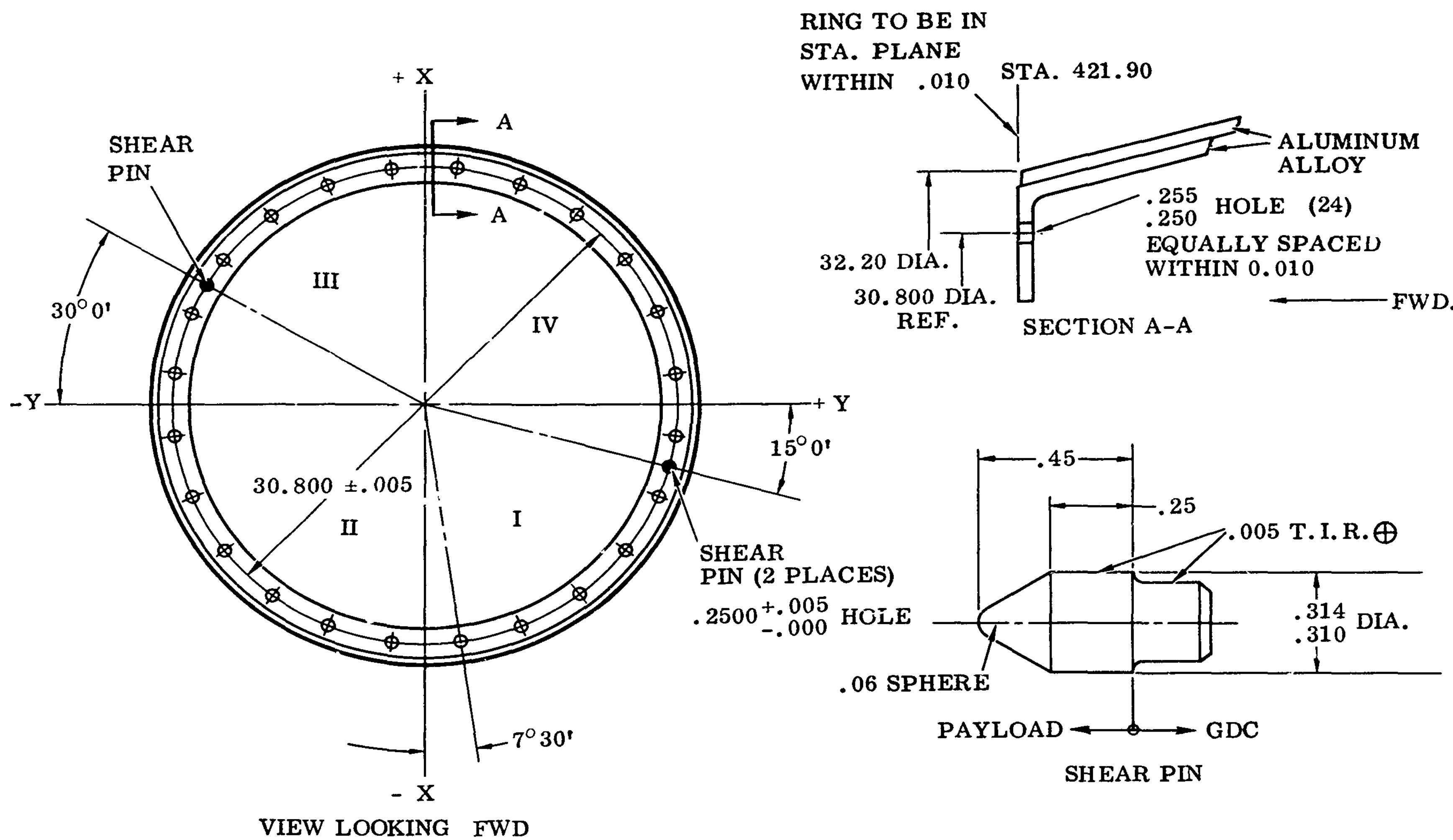
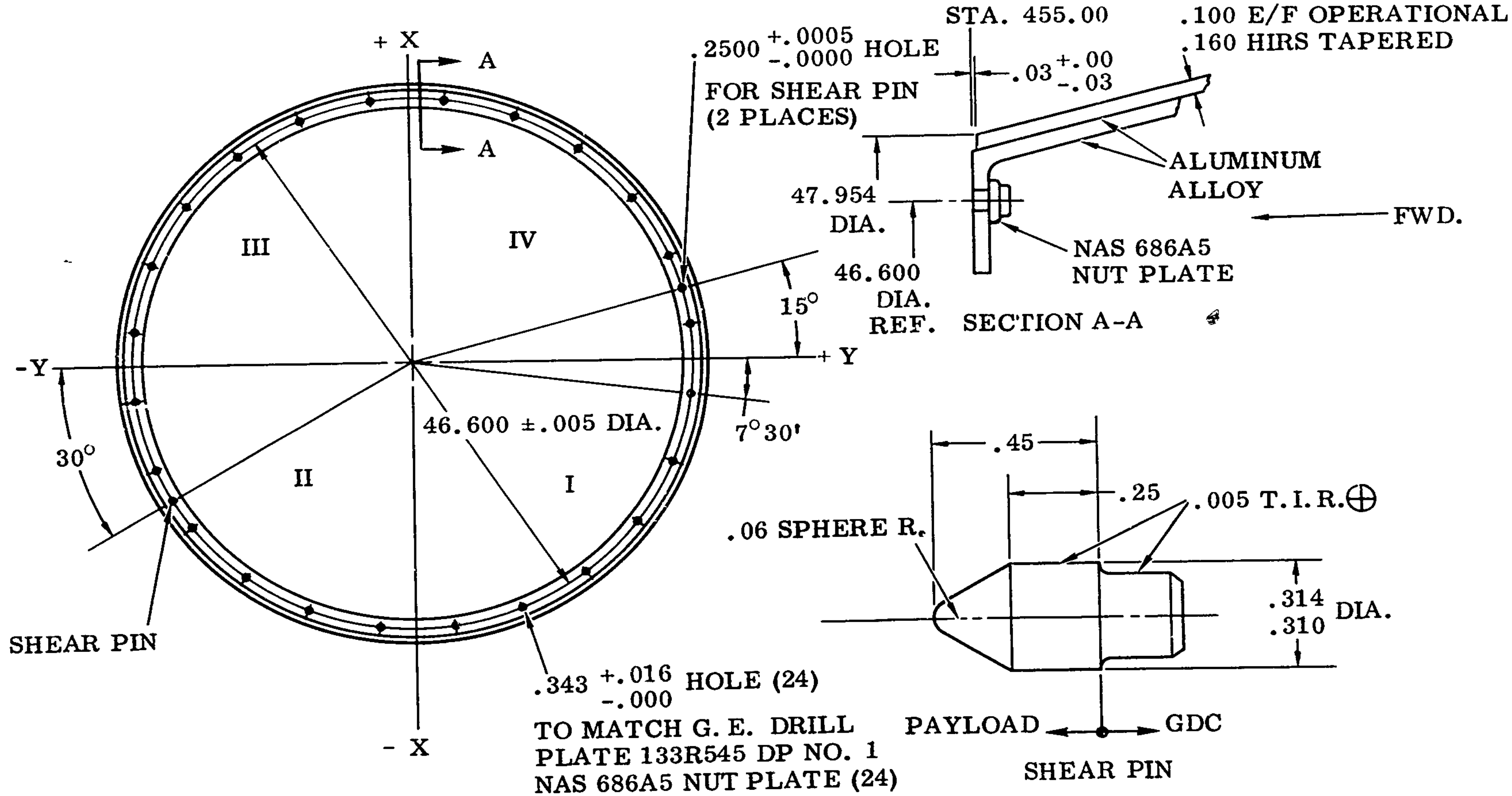


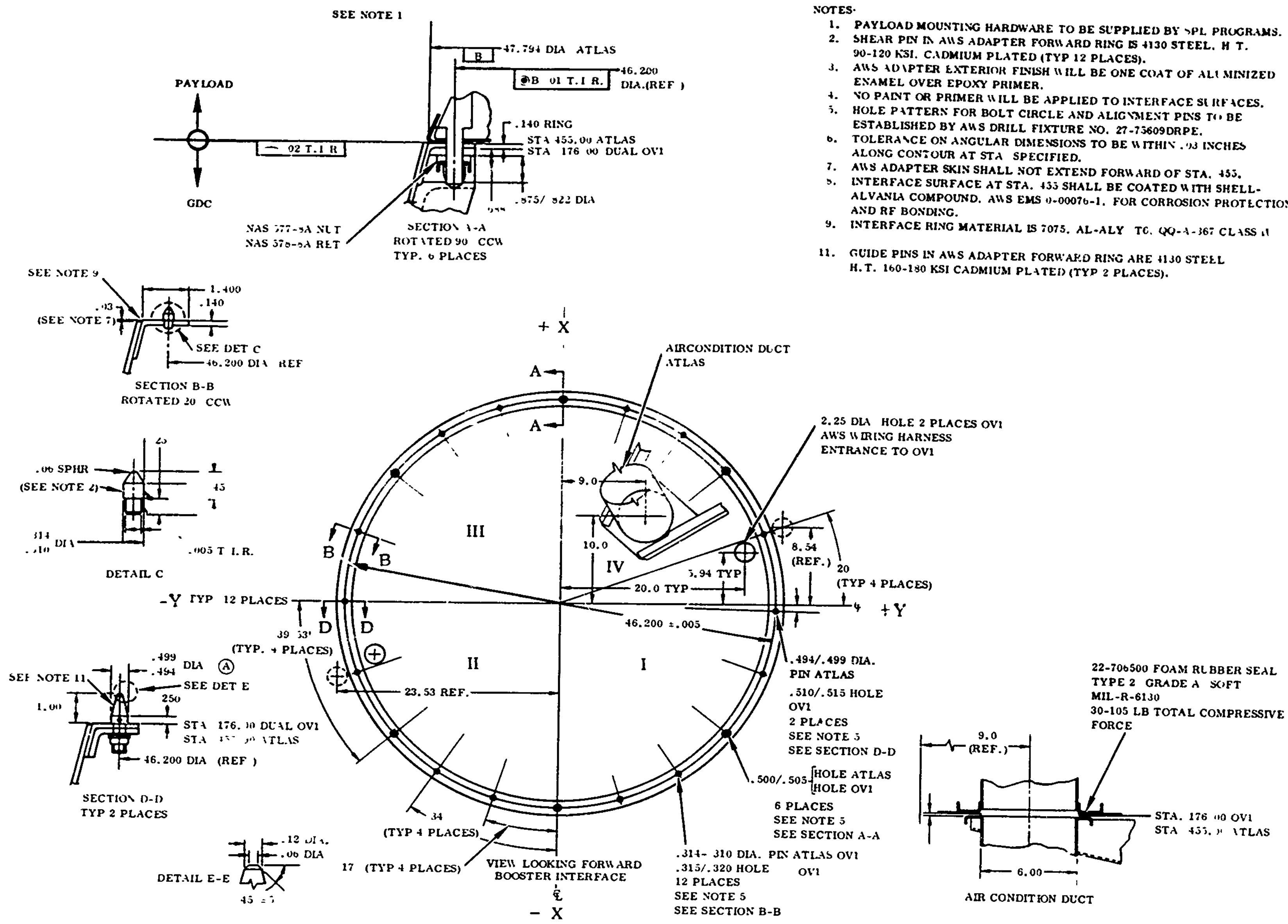
Figure 2-4. Payload Adapter Mechanical Interface, 32-inch Diameter



VIEW LOOKING FWD

THIS I/F IS TYPICAL FOR E/F OPERATIONAL ADAPTERS EXCEPT AS NOTED

Figure 2-5. Payload Adapter Mechanical Interface, 48-inch (Heavy Wall)



NOTES:
1. PAYLOAD MOUNTING HARDWARE TO BE SUPPLIED BY SPL PROGRAMS.
2. SHEAR PIN IN AWS ADAPTER FORWARD RING IS 4130 STEEL, H T. 90-120 KSI. CADMIUM PLATED (TYP 12 PLACES).
3. AWS ADAPTER EXTERIOR FINISH WILL BE ONE COAT OF ALUMINIZED ENAMEL OVER EPOXY PRIMER.
4. NO PAINT OR PRIMER WILL BE APPLIED TO INTERFACE SURFACES.
5. HOLE PATTERN FOR BOLT CIRCLE AND ALIGNMENT PINS TO BE ESTABLISHED BY AWS DRILL FIXTURE NO. 27-75609DRPE.
6. TOLERANCE ON ANGULAR DIMENSIONS TO BE WITHIN .03 INCHES ALONG CONTOUR AT STA SPECIFIED.
7. AWS ADAPTER SKIN SHALL NOT EXTEND FORWARD OF STA. 455.
8. INTERFACE SURFACE AT STA. 455 SHALL BE COATED WITH SHELL-ALVANIA COMPOUND. AWS EMS 0-00076-1. FOR CORROSION PROTECTION AND RF BONDING.
9. INTERFACE RING MATERIAL IS 7075. AL-ALY TO. QQ-A-367 CLASS 4
11. GUIDE PINS IN AWS ADAPTER FORWARD RING ARE 4130 STEEL H.T. 160-180 KSI CADMIUM PLATED (TYP 2 PLACES).

Figure 2-6. OV1 Mechanical Interface, 48-inch (Thin Wall)

NOTES.

1. 46.600±.005 DIA. AND 47.794 DIA. TO BE CONCENTRIC WITHIN .010 T.I.R. ON GDC ADAPTER. 46.600 ±.005 DIA. AND 48.000 DIA. TO BE CONCENTRIC WITHIN 010 T.I.R. ON RE-ENTRY VEHICLE SPACER.
2. HOLE PATTERN FOR BOLT CIRCLE TO BE ESTABLISHED BY G.E. DRILL PLATE NO. 133R545 - DP NO. 1
3. PAYLOAD ATTACHING HARDWARE TO BE SUPPLIED BY PAYLOAD MFGR.
4. GDC MATING MATERIAL WILL BE 7075-T6 AL-ALY FORGING.
5. ALIGNING PIN IN GDC ADAPTER FORWARD RING IS 4130 STEEL H.T. 90-125 KSI CADMIUM PLATE.
6. GDC ADAPTER EXTERIOR FINISH WILL BE ONE COAT OF ALUMINIZED ENAMEL OVER EPOXY PRIMER.
7. NO PAINT OR PRIMER WILL BE APPLIED TO INTERFACE SURFACES.
8. NO PART OF PAYLOAD SPACER SHALL PROTRUDE BELOW INTERFACE STATION 415.00, EXCEPT AS SHOWN IN SECTION A-A.
9. TARGET DIRECTION OF PAYLOAD SHALL COINCIDE WITH TARGET DIRECTION OF BOOSTER.

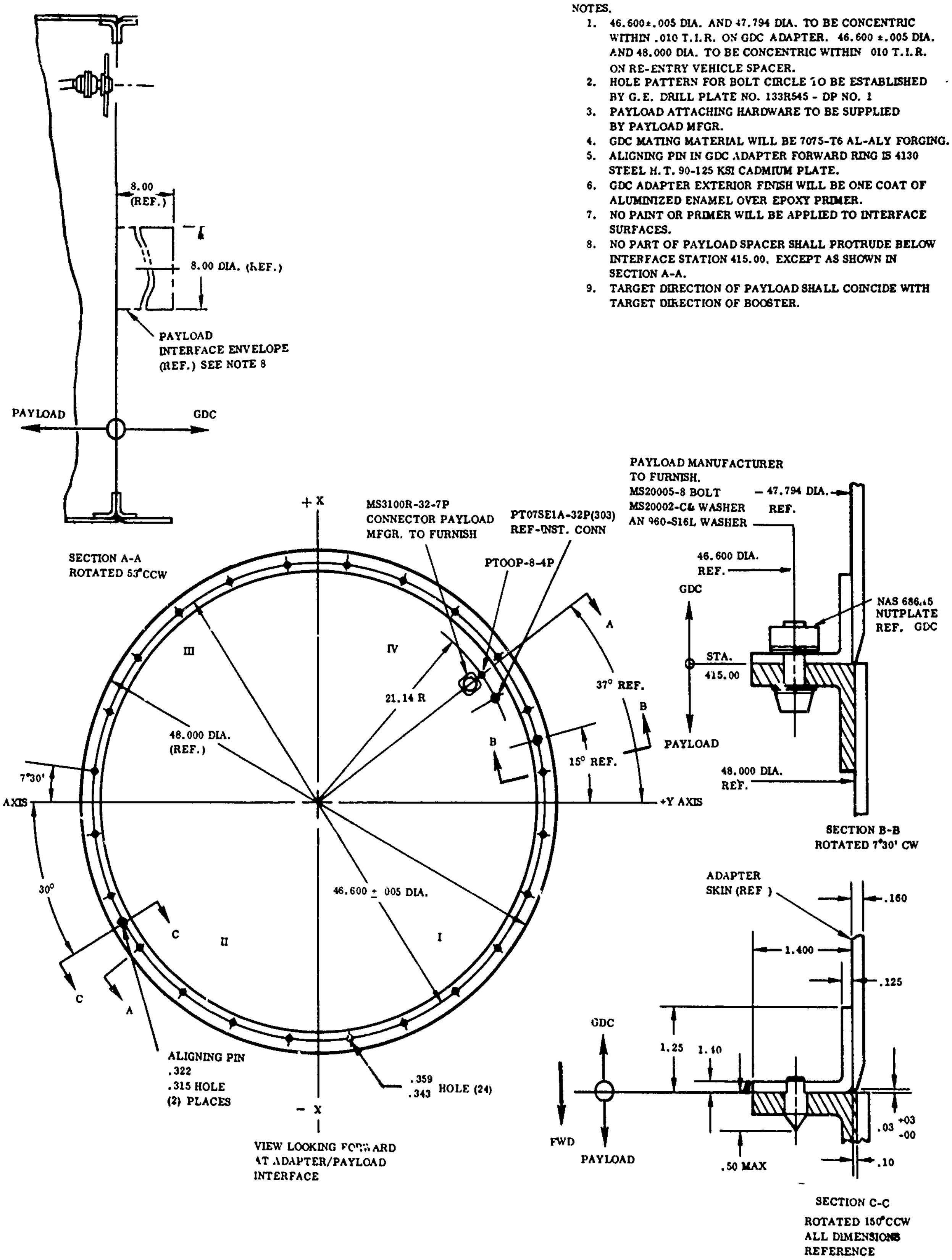


Figure 2-7. HIRS Mechanical Interface, 48-inch

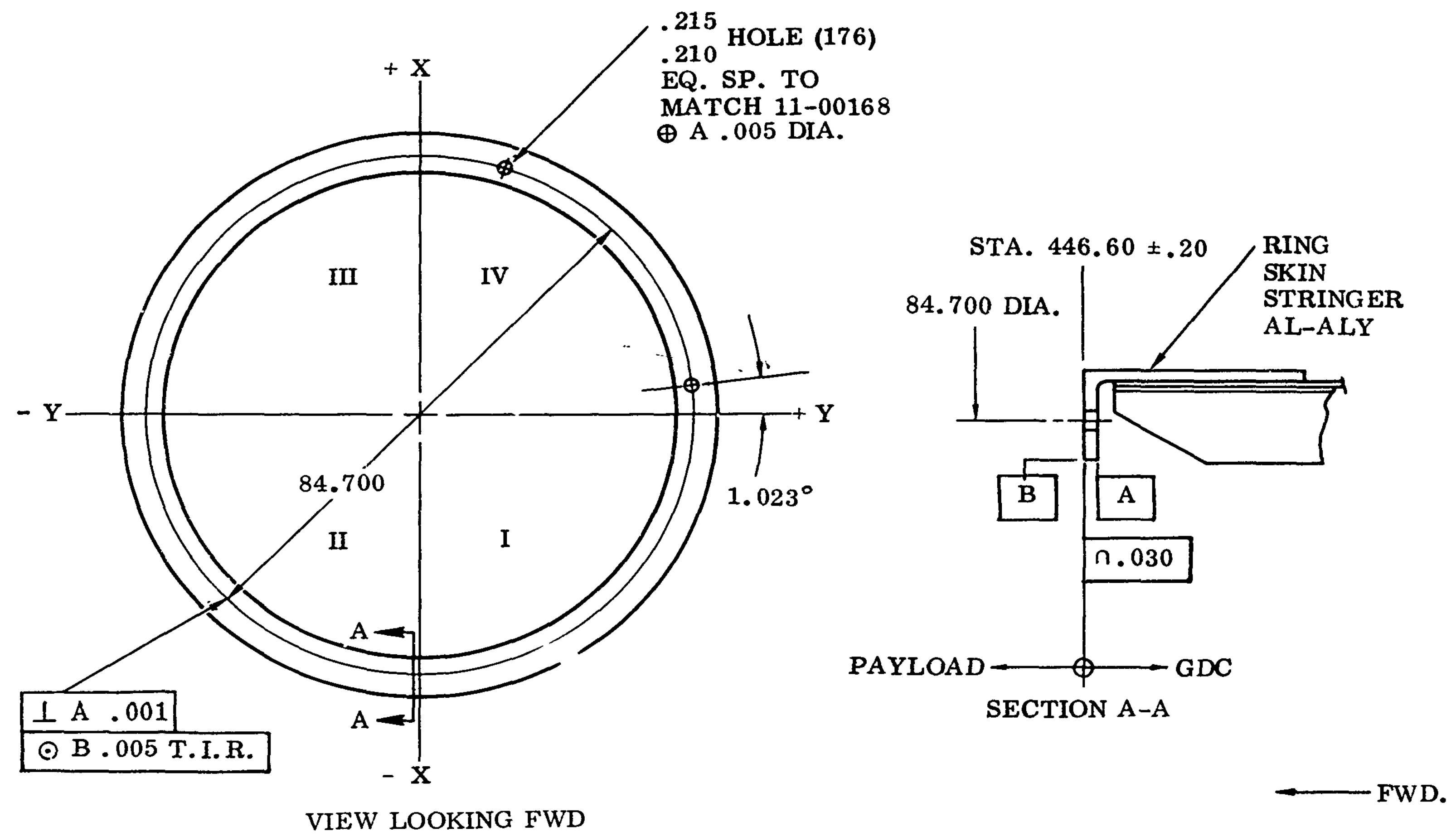
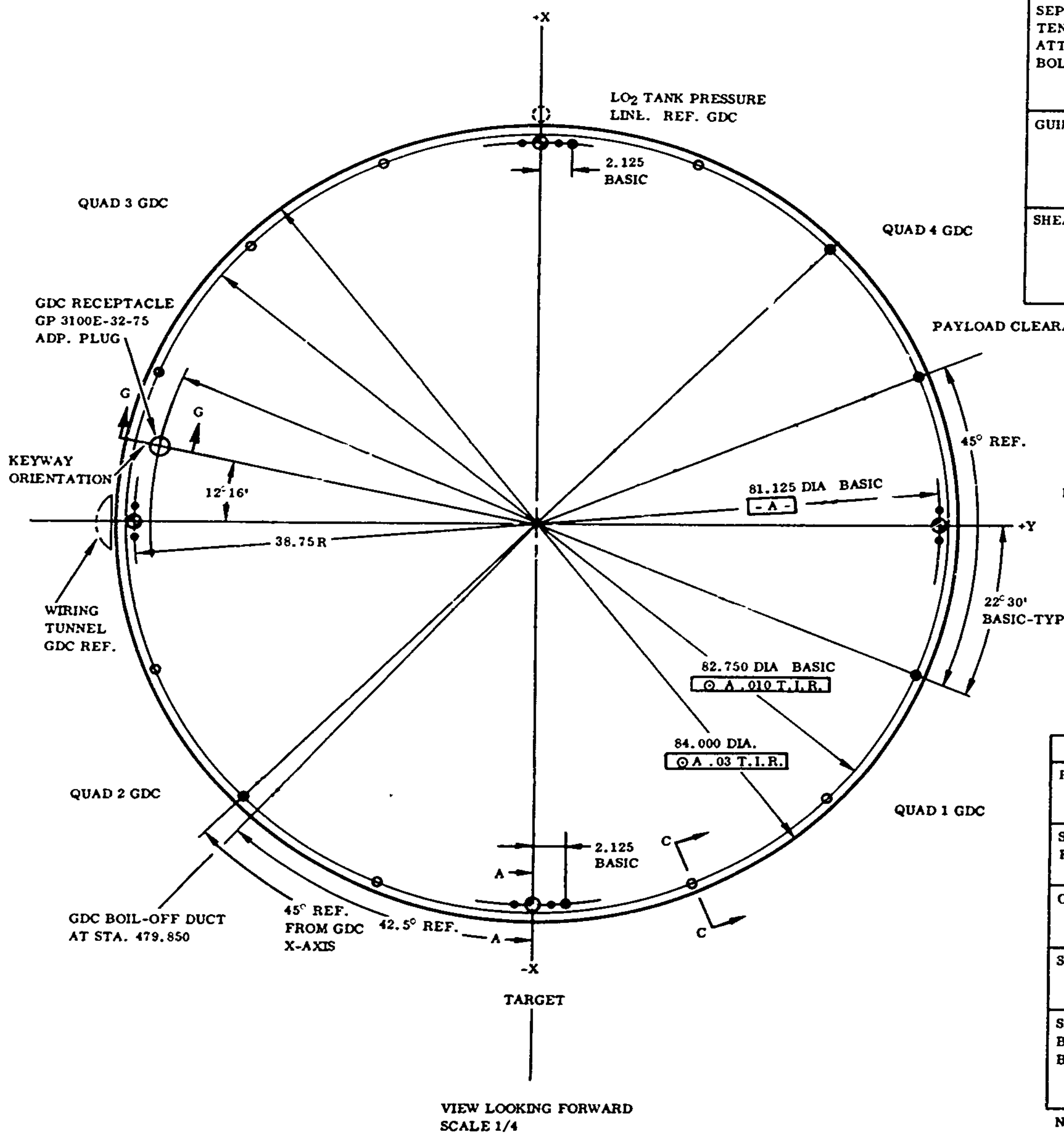


Figure 2-8. Payload Adapter Mechanical Interface, 84-inch



USAGE	CODE	HOLE SIZE REQUIREMENTS DIA. INCHES		QTY		HOLE CIRCLE
		PAYLOAD	GDC	PAYLOAD	GDC	DIA INCHES REF
SEPARATION TENSION ATTACH BOLTS	◕	.529 .541 HOLE ⊕ .010 DIA	⊕ .010 DIA .6875 +.0005 -.0000 HOLE .040 × 45° FAR SIDE	4	4	81.125 [illegible] DIA - A - SEE SECTION A-A
GUIDE PINS	◐	.510 .515 HOLE ⊕ .010 DIA	⊕ .010 DIA .358 .363 HOLE 90° CSK .414 DIA. NEAR SIDE	2	2	81.1[illegible] BASIC DIA. [illegible] SEE SECTION B-B
SHEAR PINS	⊕	.315 .320 HOLE ⊕ .010 DIA.	⊕ .010 DIA .2500 .2505 HOLE 90° CSK. .290 DIA. NEAR SIDE	12	12	82.750 BASIC DIA. ⊙A .01 T.I.R. SEE SECTION C-C

NOTES.

1. ACCESS REQUIREMENTS FOR SEPARATION-EXPLOSIVE NUTS AND ELECTRICAL INTERFACE SHALL BE PROVIDED BY PAYLOAD MANUFACTURER FORWARD OF INTERFACE STA. 447.00.
2. ACCESS FOR TORQUING OF THE FOUR SEPARATION BOLTS SHALL BE PROVIDED BY GDC AFT OF INTERFACE. STA. 447.00.
3. HOLE PATTERN FOR MECHANICAL INTERFACE TO BE ESTABLISHED BY MASTER TOOLING GAGE NO. 24S120.00.
4. SEPARATION HARDWARE, i.e. SEPARATION BOLTS AND EXPLOSIVE NUTS, TO BE FURNISHED BY PAYLOAD MANUFACTURER.
5. IN-FLIGHT ELECTRICAL DISCONNECT TO BE PROVIDED BY PAYLOAD MANUFACTURER.

INTERFACE MATERIAL AND SURFACE FINISH

PART	PAYLOAD	GDC
RINGS 447.00	7075-T6 AL-ALY CHEM FILM PER MIL-STD-1713(MR) FINISH 7.3.3	7075-T6511 AL-ALY CHEM FILM PER MIL-C-5541
SEPARATION FITTINGS	SAME AS ABOVE	7079-T6 AL-ALY CHEM FILM PER MIL-C-5541
GUIDE PINS	SAME AS ABOVE	4130 90-126 H.T ALY-STL CAD PLATE PER QQ-P-416, TYPE 1, CLASS 2
SHEAR PINS	SAME AS ABOVE	4130 150-180 H.T. ALY-STL CAD. PLATE PER QQ-P-416, TYPE 1, CLASS 2
SEPARATION BOLT BUSHING		5 CR-1.3 MO-.05 V STL H.T. TR 260-300 KSI CAD PLATE PER MIL-C-8837, CLASS 2, 1.4-1.6 MILS THICK

NOTE: PAINT OR PRIMER WILL NOT BE APPLIED TO ANY INTERFACE SURFACES GDC INTERFACE RING SHALL BE COATED WITH SHELL-ALVANIA COMPOUND GDC NO 0-00070-1 FOR CORROSION PROTECTION AND RF BONDING.

Figure 2-9. Booster Airframe to Payload Mechanical Interface, 84-inch (Sheet 1 of 2)

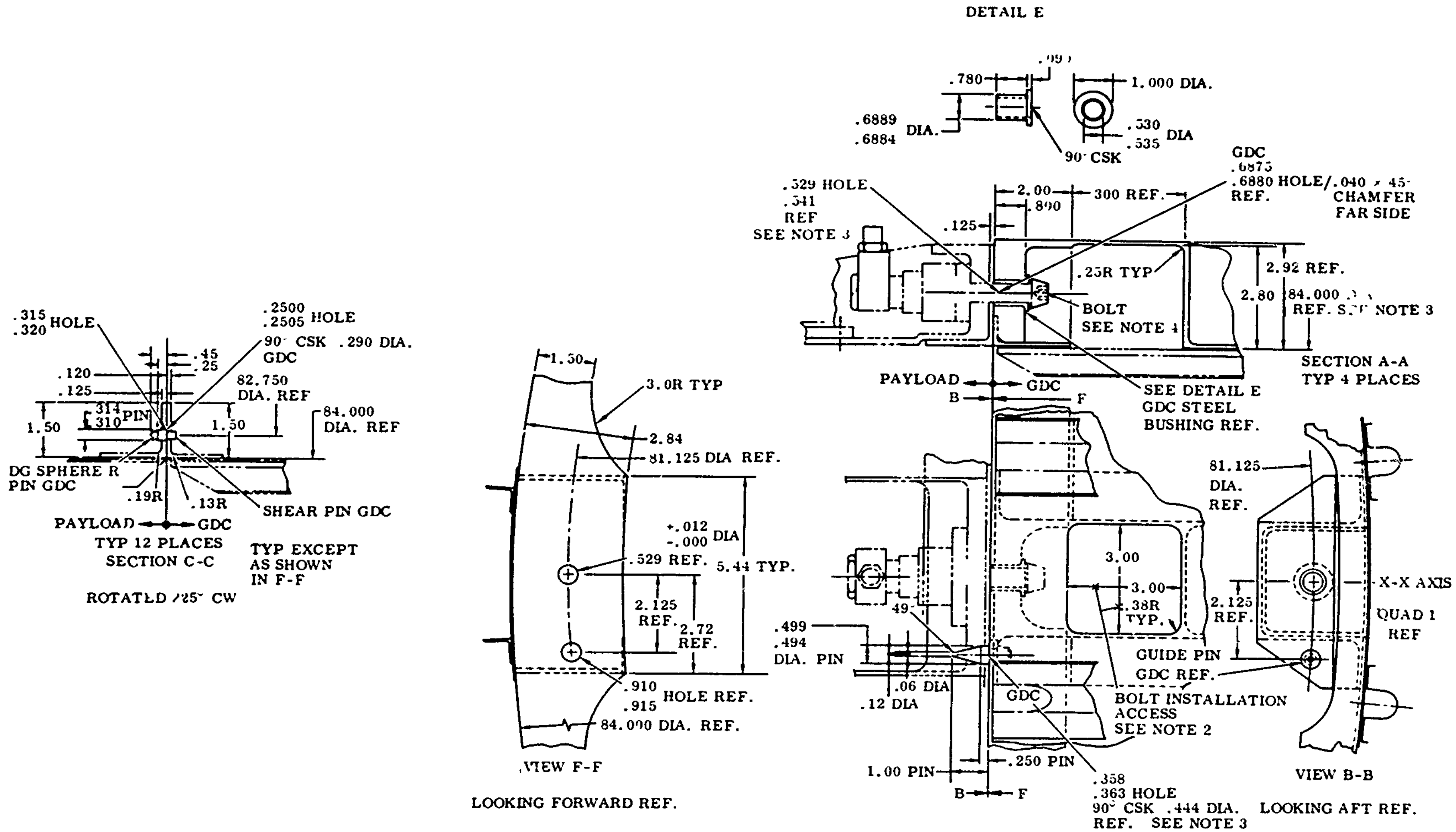


Figure 2-9. Booster Airframe to Payload Mechanical Interface, 84-inch (Sheet 2 of 2)

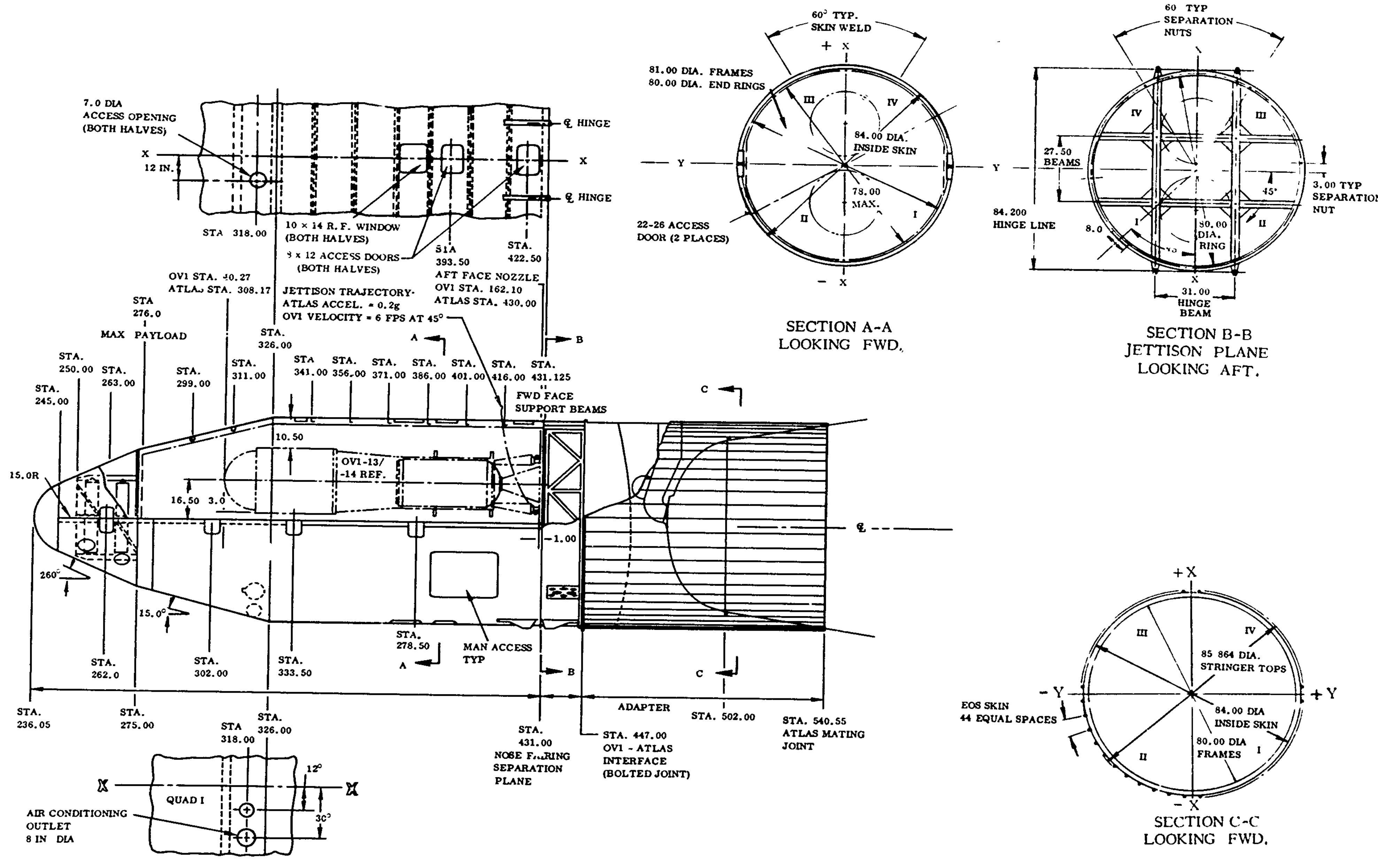


Figure 2-10. Fairing System, 84-inch

NOTES
1 THIS INTERFACE DRAWING IS LIMITED TO A MECHANICAL AND DIMENSIONAL DEFINITION OF STA 502 AREA ON THE ATLAS E/F SERIES BOOSTERS THE STRUCTURAL AERODYNAMIC AND THERMODYNAMIC RESTRAINTS ON THIS INTERFACE REQUIRE A DETAILED ANALYSIS
2 THIS HOLE PATTERN IS DEFINED BY A GDC DRILL PLATE GDC TOOLING GAGE 7-76406
3 MEANS SHALL BE PROVIDED TO PREVENT SMALL FOREIGN OBJECTS FROM BEING LODGED IN SPACE BETWEEN ADAPTER SHELL AND LO_2 FORWARD BULKHEAD
4 SURFACE INDICATED ● MUST BE HELD CONCENTRIC WITHIN THE T I R SPECIFIED
5 ALL STATION DIMENSIONS ARE IN INCHES.
6 FOR ELECTRICAL INTERFACE SEE DWG 27-04099
7 THE ADAPTER MATING RING SHALL PROVIDE FOR DRAINING OF CONDENSED LIQUID FROM GAP BETWEEN ADAPTER SHELL AND LO_2 TANK FORWARD BULKHEAD
8 RF AND ELECTRICAL BONDING BETWEEN ADAPTER AND STATION 502 00 RING SHALL BE ACHIEVED.

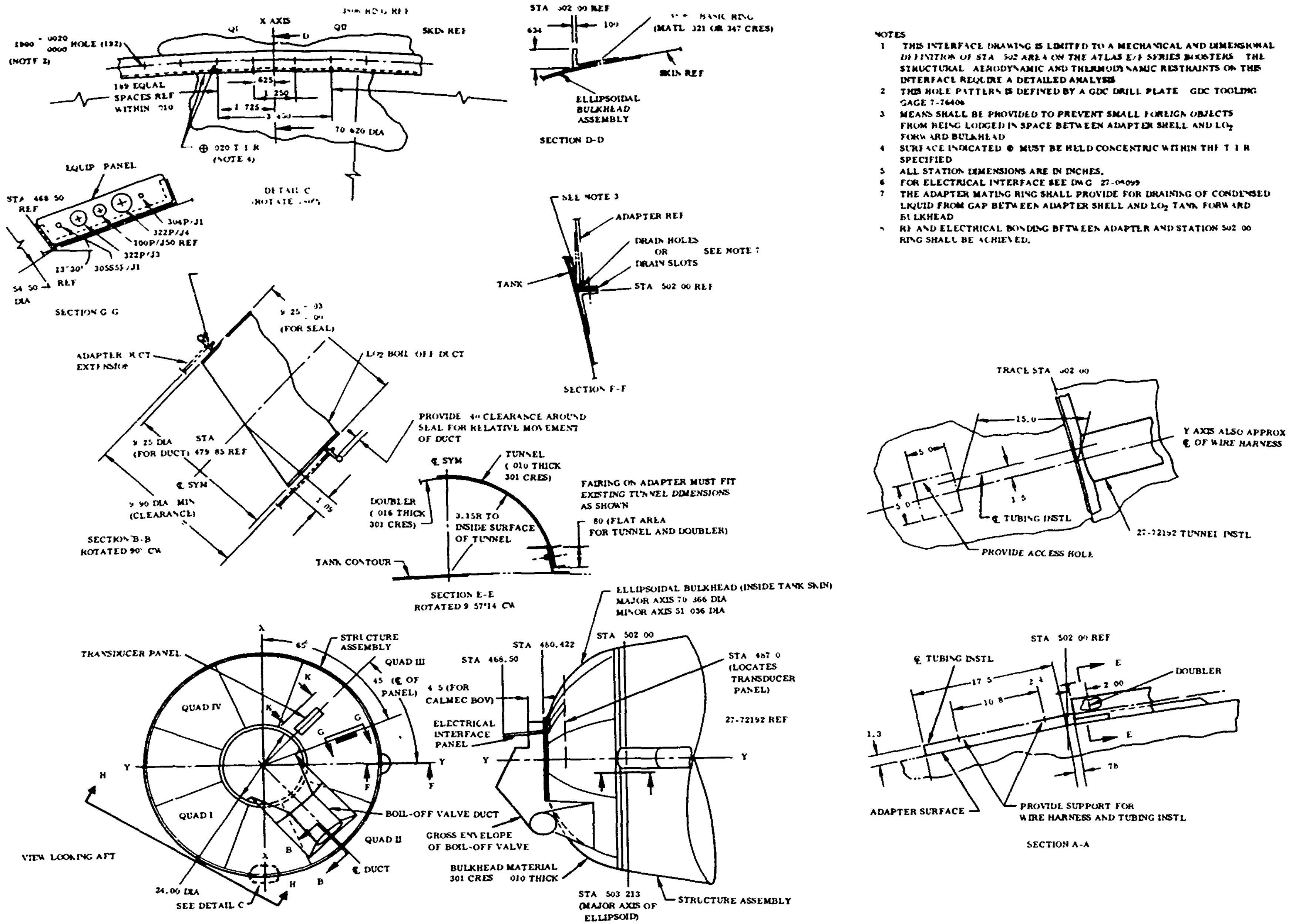


Figure 2-11. Booster Station 502 Mechanical Interface, 70-inch (Sheet 1 of 2)

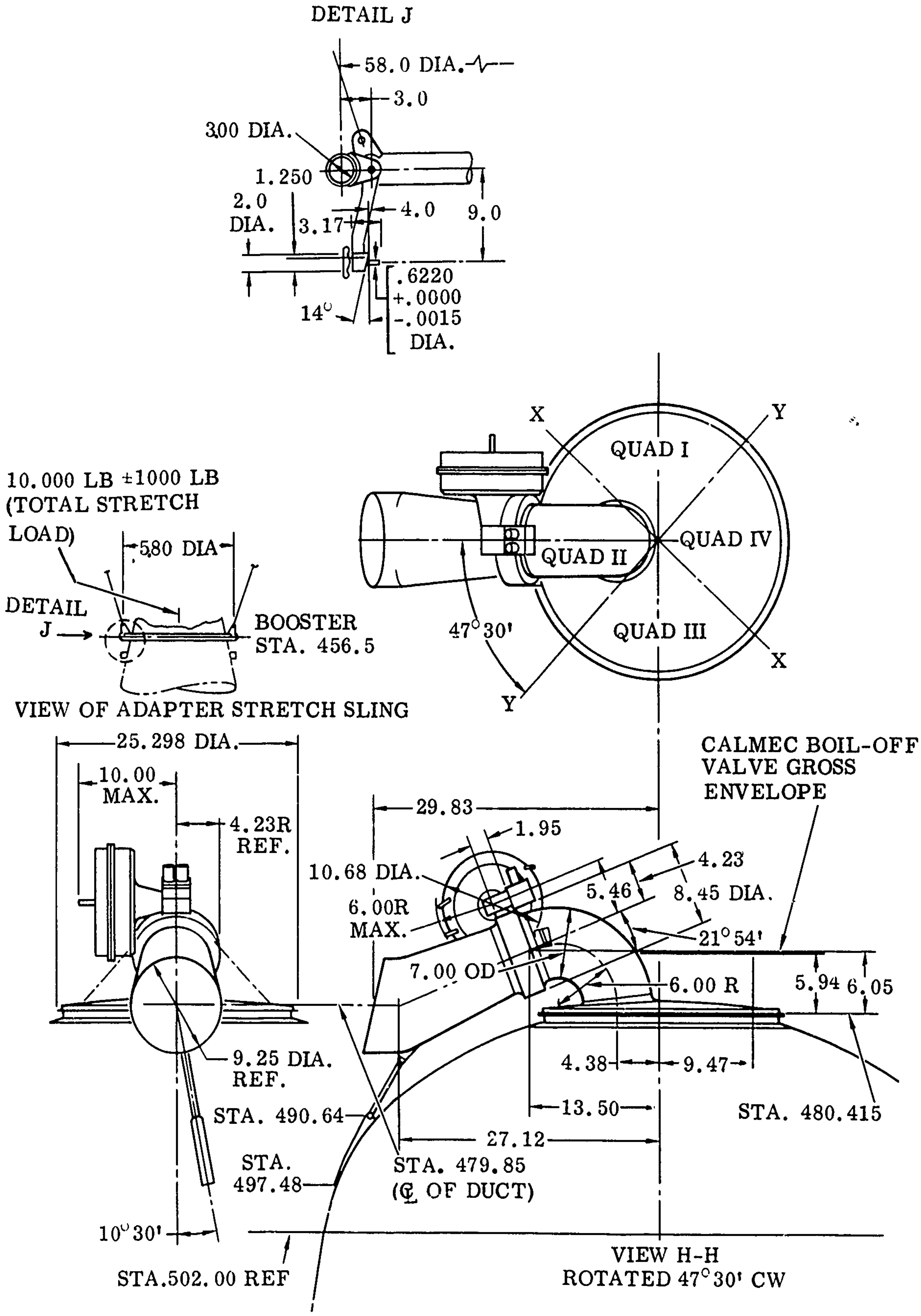


Figure 2-11. Booster Station 502 Mechanical Interface, 70-inch (Sheet 2 of 2)

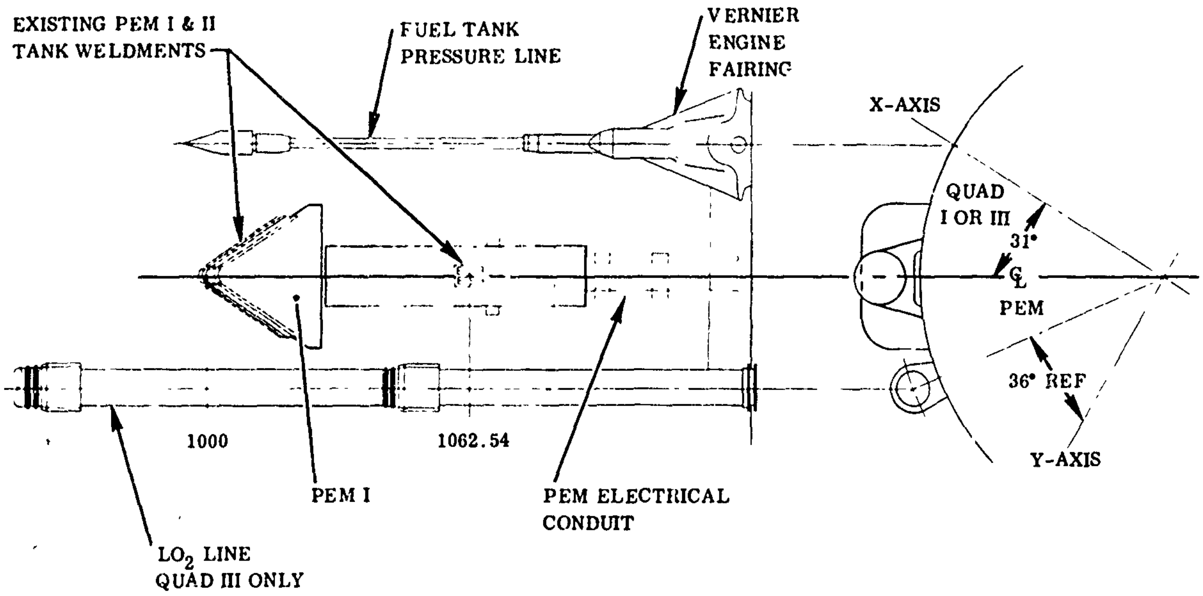


Figure 2-12. PEM I General Arrangement

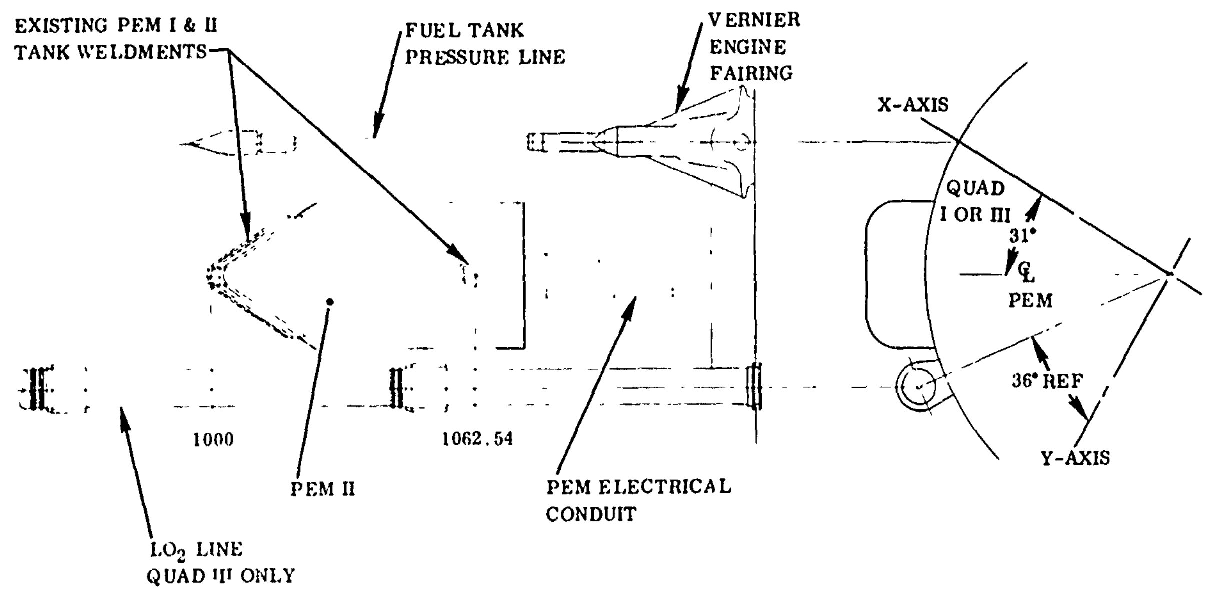


Figure 2-13. PEM II General Arrangement

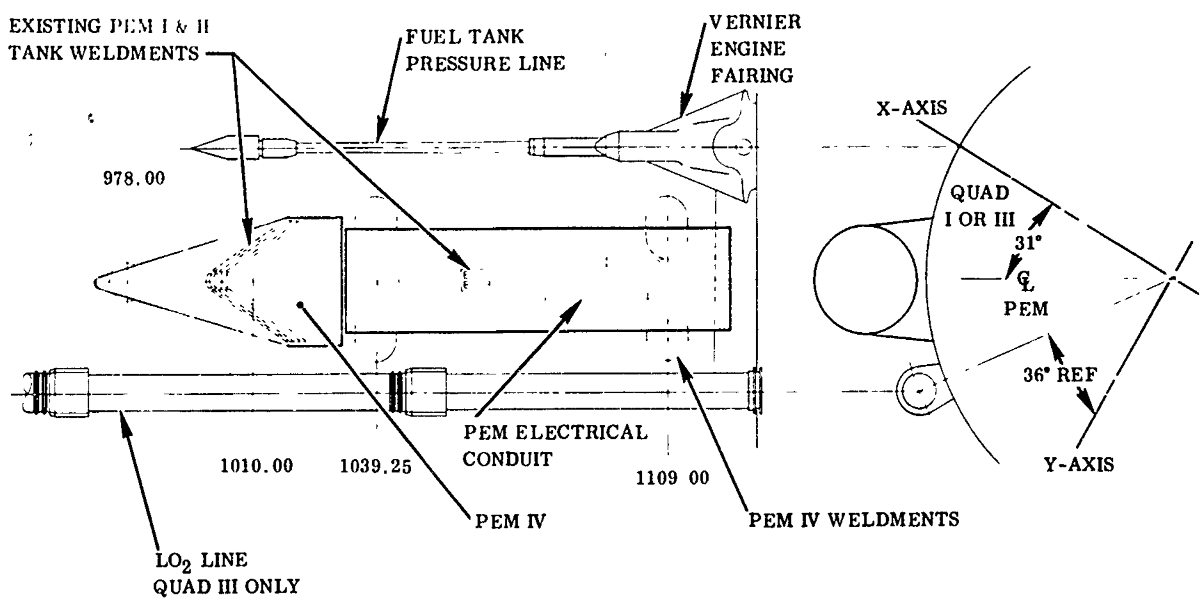


Figure 2-14. PEM IV General Arrangement

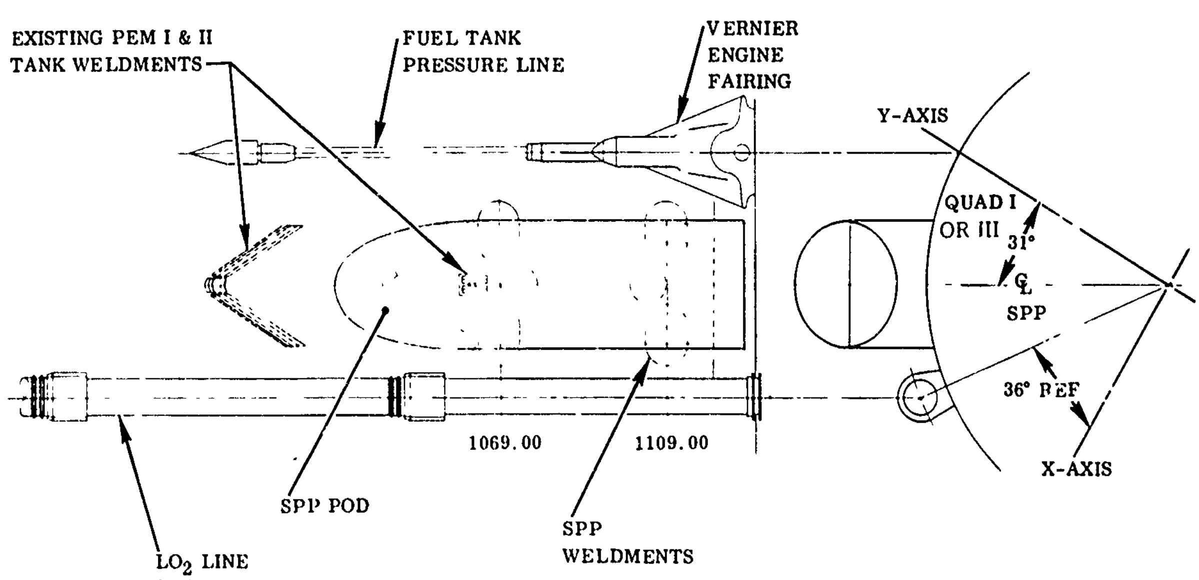


Figure 2-15. SPP General Arrangement

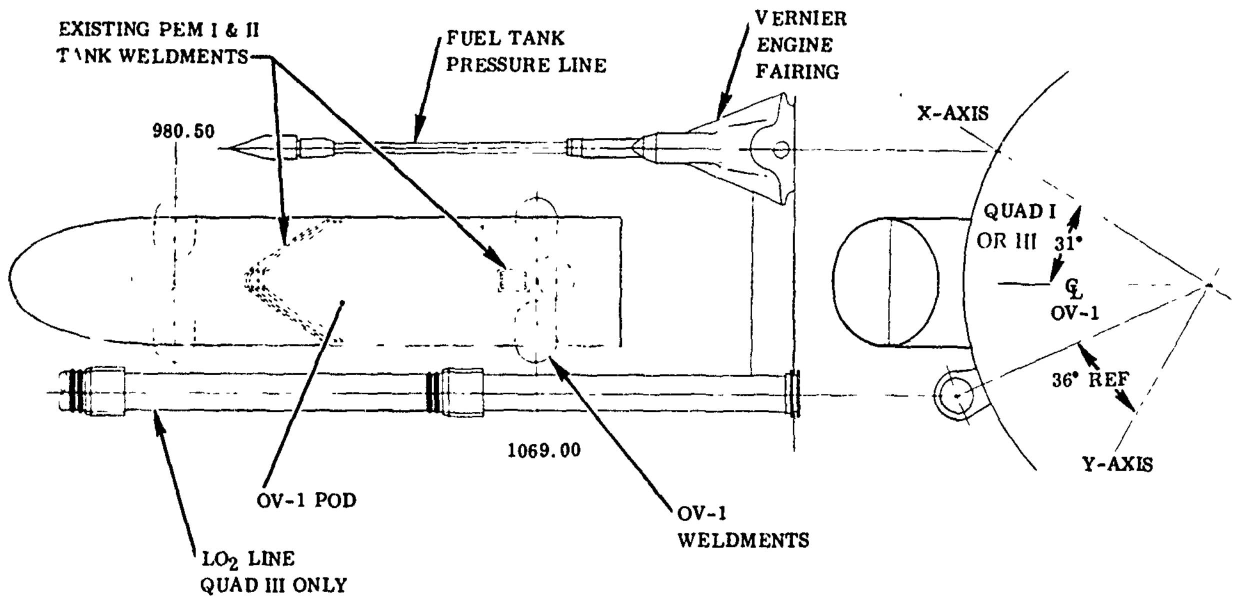


Figure 2-16. OV1 Side Mounted General Arrangement

SECTION 3
AIRBORNE ELECTRICAL CRITERIA

Electrical interface of booster/adapter and payload usually involves the following areas:

a. Power to activate or operate the payload.

b. Control functions and signal monitoring.

c. Detection of physical separation between the booster and the payload.

d. Instrumentation.

Recent incorporation of a versatile payload cabling system (see Section 10) permits the electrical interface between the payload and the booster to be reduced to an absolute minimum.

3.1 BOOSTER/PAYLOAD ELECTRICAL INTERFACE - NOSE MOUNTED PAYLOADS. Figure 3-1 depicts the baseline electrical interface for nose mounted payloads. The connector identified as 304P1 is the primary interface. The payload contractor is responsible for specifying electrical requirements of the payload circuits; assignment of electrical pins is mutually agreed upon by the payload contractor and Convair. Also, the location of the electrical interface connector on the payload spacer is mutually agreed upon before commencing design.

An inflight disconnect is normally provided by the payload contractor. Mechanical lanyard attach points, if required, are included on the mechanical interface drawings.

3.1.1 Electrical Connectors. The payload contractor provides receptacle connectors and Convair provides interfacing plug connectors. The receptacles are mounted on the payload spacer in such a way that the connector keyway is oriented radially outboard in a plane through the booster vertical centerline.

3.1.2 Separation Signal Connector. The payload contractor is responsible for providing a PT00P-8-4P receptacle from the payload mounted separation switch. The pins required are the same as those indicated for connector 305S5P1 in Figure 3-1. The circuit must be capable of carrying three amps at 28 vdc and the total resistance must not exceed two ohms. Convair is responsible for supplying the mating plug (PT06E-8-4S) and the 28-vdc power.

3.1.3 Payload - AGE Electrical Connector. This connector, provided by the payload contractor, is usually side mounted on either the payload, payload spacer, or the payload adapter (non-standard). Convair has considerable experience with these connectors and will assist wherever possible in making the selection. Considerable time and cost can be saved by utilizing existing connectors and umbilical cables. (See Table 10-6.)

3.1.4 Instrumentation Signal Connector. If payload functions are telemetered through the booster telemetry system, it is required that the 304P1 circuits be used if possible. If mission requirements exceed 304P1 circuit capability, a suitable interface is negotiated between the payload contractor and Convair. A 32-pin instrumentation harness design is available and may be used to satisfy mission requirements. Section 9 describes the existing instrumentation capability.

3.1.5 Booster/Payload Electrical Interface - Side Mounted Payloads. The booster is equipped with interface connectors as shown in Figure 3-2. The payload contractor is required to provide appropriate receptacles.

The 322P3 and 322P4 connectors (Figure 3-1) are reserved for the HIRS and are not intended for use by the payload.

3.2 SEPARATION SWITCH. The payload contractor is required to provide a separation switch, associated harness, and an interface connector in the payload spacer. The purpose of this switch is to provide a switch closure which will enable a payload separation signal to the booster only after the payload has physically separated from its spacer.

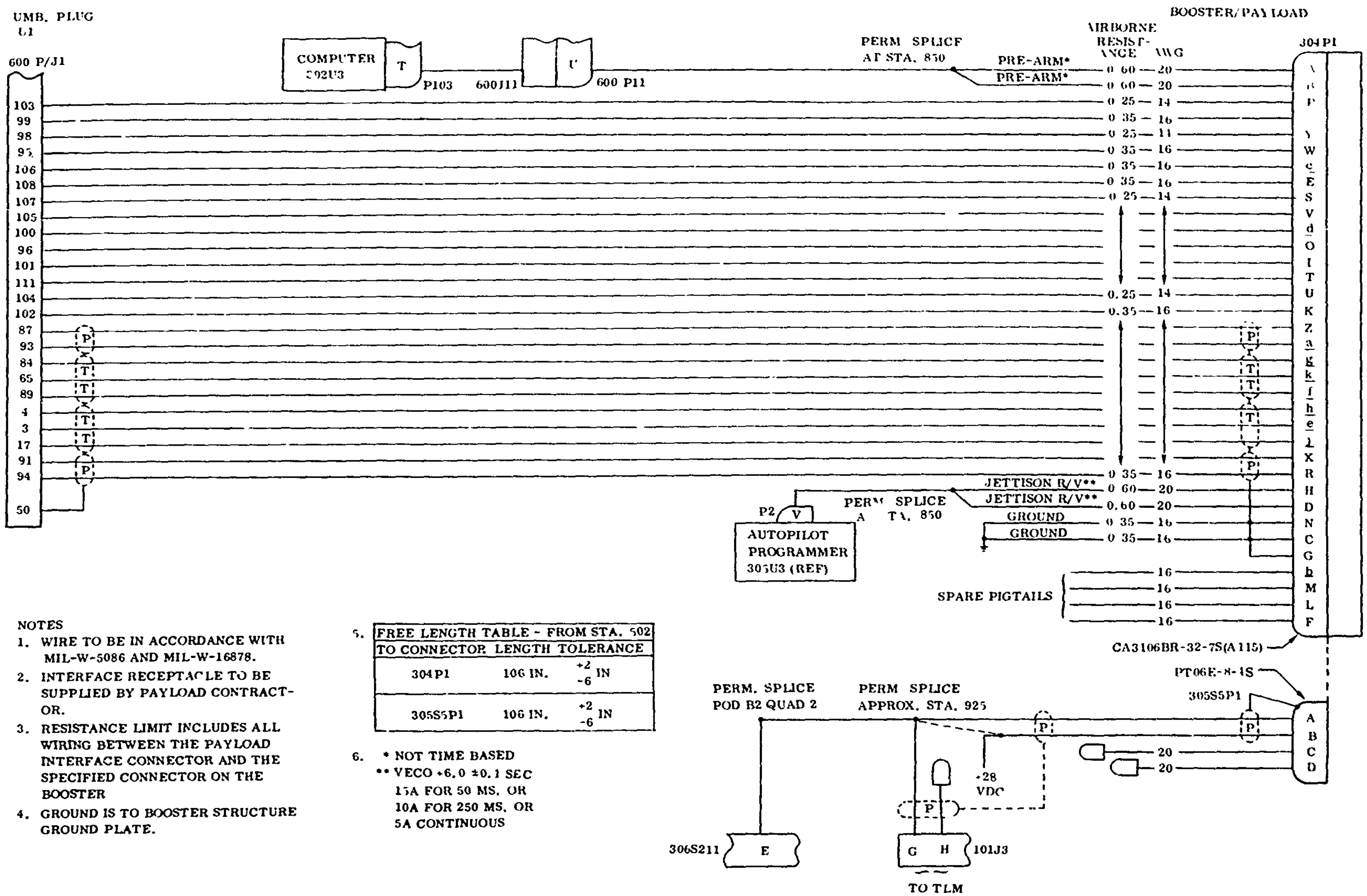
3.3 INTERFACE DISCRETES. Convair will provide required booster discrete functions such as fairing eject, vernier engine cutoff (VECO), payload arming, payload separation, etc., through connector 304P1. The payload contractor is required to furnish any protection required against voltage transients within the specified voltage range of 24 to 30 vdc. In the zero state (prior to discrete command), spurious voltages in excess of ± 2.25 volts are not allowed.

Certain types of discretes require the use of a discrete timer. Convair has developed a timer which provides up to six discretes which may be delayed up to 30 seconds from an activation signal. The discrete timer is used primarily to provide high current discretes and discrete commands not available at certain times in the flight.

The discrete timer is capable of delivering 16 amps maximum at 24 to 30 vdc for each channel.

The pre-arm discrete (Figure 3-1) is capable of providing a current of 0.5 ampere and occurs at VECO +1 second nominal.

Reentry vehicle jettison is an autopilot discrete that occurs at VECO +6 seconds and is capable of providing the currents shown in Figure 3-1.



NOTES
1. WIRE TO BE IN ACCORDANCE WITH MIL-W-5086 AND MIL-W-16878.
2. INTERFACE RECEPTACLE TO BE SUPPLIED BY PAYLOAD CONTRACTOR.
3. RESISTANCE LIMIT INCLUDES ALL WIRING BETWEEN THE PAYLOAD INTERFACE CONNECTOR AND THE SPECIFIED CONNECTOR ON THE BOOSTER
4. GROUND IS TO BOOSTER STRUCTURE GROUND PLATE.
5.

FREE LENGTH TABLE - FROM STA. 502		
TO CONNECTOR	LENGTH	TOLERANCE
304P1	106 IN.	+2 -6 IN
305S5P1	106 IN.	+2 -6 IN

6. * NOT TIME BASED
** VECO +6.0 ±0.1 SEC
15A FOR 50 MS, OR
10A FOR 250 MS, OR
5A CONTINUOUS

Figure 3-1. Booster Baseline Electrical Interface

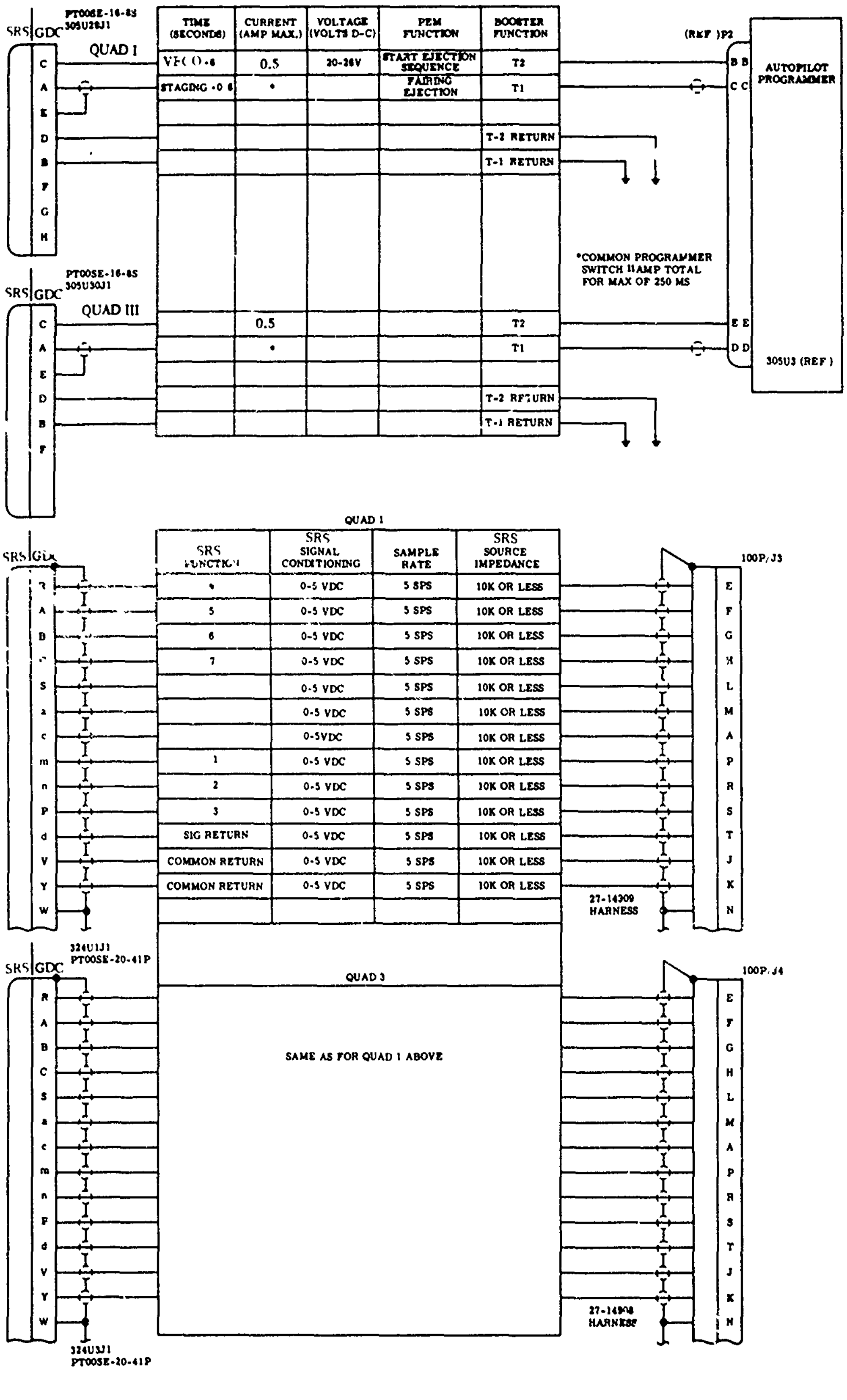


Figure 3-2. Side-Mounted Payloads Quads I and III Electrical Interface

SECTION 4
MASS PROPERTIES

Mass properties data are presented for E/F boosters equipped with inertial guidance system, E/F boosters equipped with radio guidance system, payload adapters, and for other optional equipment commonly used in support of mission requirements. The data are typical but will vary because of differences in hardware required to support each mission. See Figures 2-1 and 10-29 for definition of coordinate system.

4.1 MASS PROPERTIES OF E/F BOOSTERS EQUIPPED WITH AIG SYSTEM. Table 4-1 gives the mass properties of E/F boosters equipped with AIG system . These data are based on booster 121F weights, without payload. Refer to Payload Definition, paragraph 1.1.

Table 4-1. Mass Properties of E/F Boosters Equipped with AIG System

	WEIGHT	Z BAR	Y BAR	X BAR	I_{ZZ}	I_{YY}	I_{XX}
Lift-off	263273	856.3	-0.4	+0.3	11808	2029982	2036498
Booster Section	7301	1216.1	-0.2	+2.9	6428.7	3117.6	7373.8
Sustainer Engine Cutoff	7435	1035.8	-12.7	+3.1	4328.6	57893.9	59588.3
Vernier Engine Cutoff	7225	1031.5	-14.0	+3.0	225.0	56730.3	58323.8

4.2 MASS PROPERTIES OF E/F BOOSTERS EQUIPPED WITH RADIO GUIDANCE SYSTEM . Table 4-2 gives the mass properties of E/F boosters equipped with radio guidance system . These data are based on booster 122F weights, without payload. Refer to Payload Definition, paragraph 1.1.

Table 4-2. Mass Properties of E/F Boosters Equipped with Radio Guidance System

	WEIGHT	Z BAR	Y BAR	X BAR	I_{ZZ}	I_{YY}	I_{XX}
Lift-off	262615	856.2	-0.2	+0.3	10927	2014183	2019755
Booster Section	7323	1216.0	-0.0	+2.9	6423.5	3123.0	7479.2
Sustainer Engine Cutoff	6755	1030.4	-6.5	+2.6	3469.1	53066.6	54039.6
Vernier Engine Cutoff	6545	1026.0	-7.9	+2.5	3373.4	51710.4	52580.3

4.3 PAYLOAD ADAPTERS WEIGHT AND CENTER OF GRAVITY (C.G.) DATA. Table 4-3 gives the weight and C.G. data for payload adapters currently available.

Table 4-3. Payload Adapters Weight and C. G. Data

ADAPTER	WEIGHT (pounds)	C.G. Z BAR (Booster Station)	C.G. Y BAR (inches)	C.G. X BAR (inches)
32-inch ABRES (Figure 2-4)	292.0	467.0	0.0	0.0
48-inch Heavy Wall (Figure 2-5)	213.0	480.0	0.0	0.0
48-inch Thin Wall (Figure 2-6)	126.0	480.0	-2.2	-1.7
48-inch HIRS with Retrorockets (Figure 2-7), 8-1	579.6	453.7	-0.4	+0.1
84-inch RMP-B (Figure 2-8)	352.0	487.0	-0.3	+0.4
84-inch Fairing System (Figure 2-10)	1329.3	367.2	+0.3	-0.3
84-inch Adapter (Figure 2-8)	320.5	489.4	-0.3	+0.4

4.4 OPTIONAL EQUIPMENT WEIGHT DATA. The weight of optional equipment available to support mission requirements is given in Table 4-4.

Table 4-4. Optional Equipment Weight

EQUIPMENT	WEIGHT (pounds)
Atlas Retrorockets (2) and Mounts	10.0
Thor Retrorockets (2) and Mounts	37.3
MOD IV PEM Weldments (2) and Insulation	40.6
MOD IV Bolt-on Kit (2)	37.4
84-inch Adapter Ring	17.8
84-inch Adapter Ring Thermal Fairing	16.0
84-inch Adapter LO_2 Line/Wire Tunnel Cover	5.5

4.5 MASS PROPERTIES DEFINITIONS

ABBREVIATION	DESCRIPTION	UNITS
Z Axis	The longitudinal axis represented by a left-hand cartesian coordinate system and passing through the centerline of the vehicle.	
Y Axis	The lateral axis represented by a left-hand cartesian coordinate system and parallel to a plane passing through the vehicle engines.	
X Axis	The vertical axis represented by a left-hand cartesian coordinate system and normal to a plane passing through the booster engines.	
Z Bar	Center of gravity of booster with respect to Z axis.	Inches (Missile Station)
Y Bar	Center of gravity of vehicle with respect to Y axis.	Inches
X Bar	Center of gravity of vehicle with respect to X axis.	Inches
I_{ZZ}	Moment of inertia about an axis passing through the vehicle center of gravity and parallel to the Z axis (also called roll inertia).	Slug Ft.^{2}
I_{YY}	Moment of inertia about an axis passing through the vehicle center of gravity and parallel to the Y axis.	Slug Ft.^{2}
I_{XX}	Moment of inertia about an axis passing through the vehicle center of gravity and parallel to the X axis.	Slug Ft.^{2}
PRIZY	Product of inertia of the vehicle with respect to two planes intersecting at the center of gravity of the vehicle and parallel to the Z and Y coordinate planes which are parallel to the X axis.	Slug Ft.^{2}
PRIZX	Product of inertia of the vehicle with respect to two planes intersecting at the center of gravity of the vehicle and parallel to the Z and X coordinate planes which are parallel to the Y axis.	Slug Ft.^{2}
PRIXY	Product of inertia of the vehicle with respect to two planes intersecting at the center of gravity of the vehicle and parallel to the X and Y coordinate planes which are parallel to the Z axis.	Slug Ft.^{2}

SECTION 5
STRUCTURAL DYNAMIC ENVIRONMENT

This section presents structural load criteria that must be considered by payload contractors in the design of their respective payloads. Structural criteria is presented for payloads mounted on booster station 502 (nose mounted), for side-mounted auxiliary payloads, and for testing payload components and bracketry.

The structural environment of payloads due to booster thrust build-up and lift-off conditions, aerodynamic loads, longitudinal acceleration, propellant sloshing and acoustic noise is discussed in detail in the following paragraphs.

5.1 NOSE-MOUNTED PAYLOAD STRUCTURAL ENVIRONMENT

5.1.1 Thrust Build-up and Lift-off Environment. Engine thrust and thrust-rise characteristics, encountered during the lift-off phase, cause an excitation of the booster which results in a transient response of the various component sections, depending on their elastic characteristics. These transient accelerations at the payload center of gravity exhibit the following conditions:

a. Predominant frequencies: Below 40 Hz

b. Longitudinal transient amplitude: 1.0 ± 4.0 g's

c. Lateral transient amplitude: ± 1.0 g

5.1.2 Maximum Aerodynamic Loads. Maximum aerodynamic loads encountered during flight consist of the lateral loads due to wind and gust forces and aerodynamic drag. The effect of acceleration loads must also be included in determining the total load, and therefore, is included in this discussion.

The time of occurrence and amplitude of the winds due to aerodynamic and inertia forces acting on the payload during the boost phase will vary depending on the particular wind profile and payload shape. Limitations are defined through use of the discrete Avidyne wind criterion used to determine the flight parameters necessary for total systems loads computations. Rigid body trajectory simulations use the Avidyne winds at maximum flight loading conditions where alpha q or beta q is a maximum. Alpha and beta are angles of attack in the pitch and yaw planes respectively, and q is the aerodynamic pressure. This is demonstrated by the equation for the aerodynamic normal force:

$$N = (C_N/\alpha)\, S_{Ref}\, \alpha\, q$$

Where S_{Ref}, the reference area, is a constant, and C_N/α, the normal force derivative, is relatively constant for short periods of time, leaving the alpha q term as the determining factor for a peak force.

The exposed payload structure should be designed for the following conditions, assuming that the payload and adapter are cantilevered from booster Station 502:

a. Aerodynamic drag due to a dynamic pressure of 1100 pounds per square foot at Mach 1.8.

b. Longitudinal acceleration of 2.5 g's.

c. Lateral loading due to alpha q of 7500 degree pounds per square foot at Mach 1.8, where alpha q is the product of angle of attack and dynamic pressure.

The above conditions may result in a conservative structure for large payloads when booster strength at booster Station 502 is considered. Therefore, the lateral loads for large payloads may be reduced until the allowable loads at booster Station 502 are satisfied by the relationship given by

$$\frac{BM_L}{1.44 \times 10^6 \text{ in.-lb}} + \frac{P_L}{74,600 \text{ lb}} = 1$$

where BM_L and P_L are limit bending moment and longitudinal load, respectively, at booster Station 502 and are determined by stress calculations. These limits are a function of payload weight and trajectory parameters and are provided by Convair after initial dynamic analyses.

Atmospheric winds can be monitored prior to launch to determine if wind conditions are satisfactory for boosters with large payloads. These wind conditions are examined in trajectory simulations to ensure that bending moment does not exceed the allowables.

5.1.3 Maximum Longitudinal Acceleration. Maximum longitudinal acceleration is accompanied by a corresponding lateral acceleration caused by propellant sloshing. Maximum propellant sloshing, shown in Figure 5-1, usually occurs near the time of maximum longitudinal acceleration for payloads weighing less than 2,350 pounds, and later for payloads weighing more than 2,350 pounds. Payload weights and applicable acceleration values are:

a. Less than 2000 lb, forward of Station 502:

   1. Longitudinal acceleration: 10 g's

   2. Lateral acceleration: 1 g

b. More than 2,350 lb, forward of Station 502:

1. Longitudinal acceleration: 8 g's

2. Lateral acceleration: See "BECO" curve of Figure 5-1

5.1.4 Acoustic Environment at Booster Station 502. Relatively high acoustic levels occur during two phases of flight: 1) launch phase; and 2) transonic-maximum dynamic pressure phase. The engines are the primary source of noise during launch; and the expected acoustic level is based on past flight and captive test data. The acoustic levels during the transonic-maximum dynamic pressure phase are the result of aerodynamic noise which is a function of the vehicle's shape. The overall and octave band acoustic levels are presented in Figure 5-2. The values in decibels are referenced to 0.0002 dynes per square centimeter (microbar).

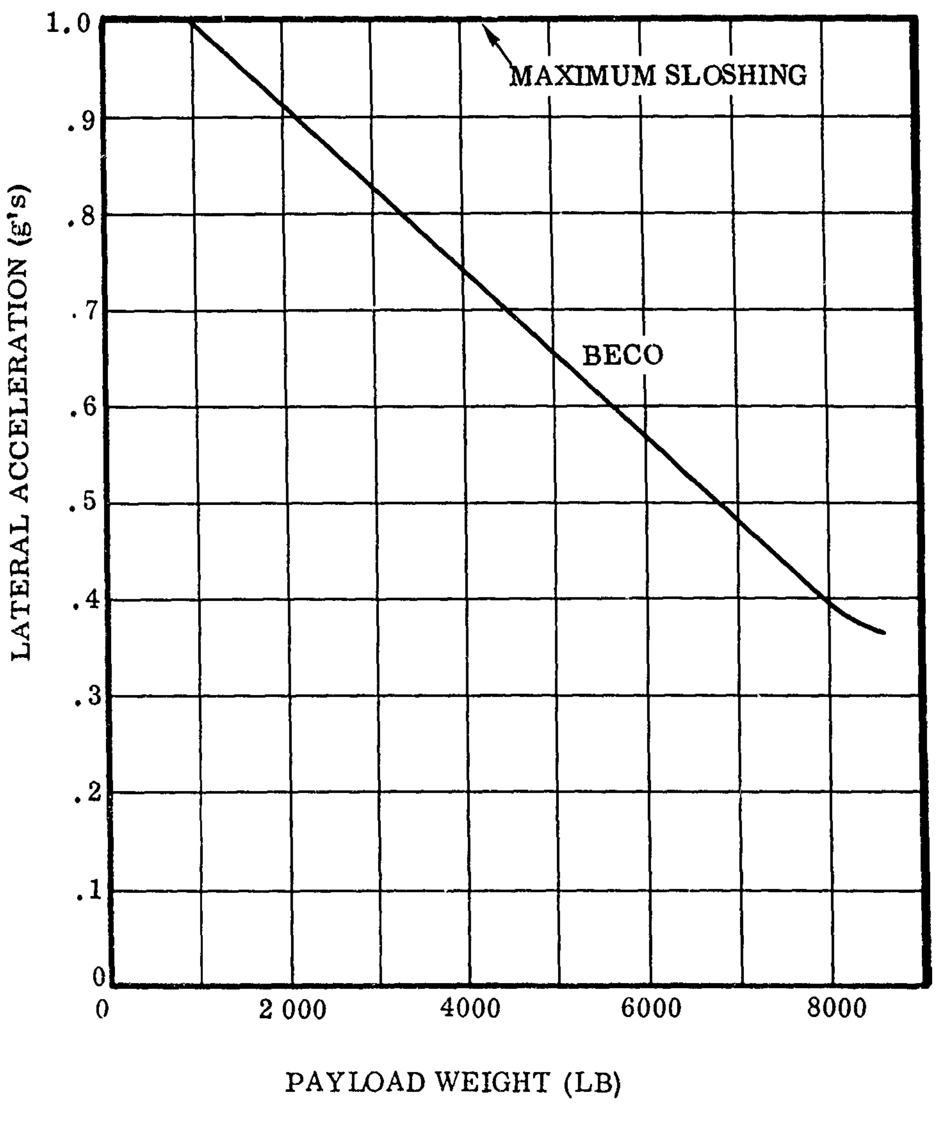


Figure 5-1. Lateral Acceleration of Payload at Maximum Sloshing and BECO

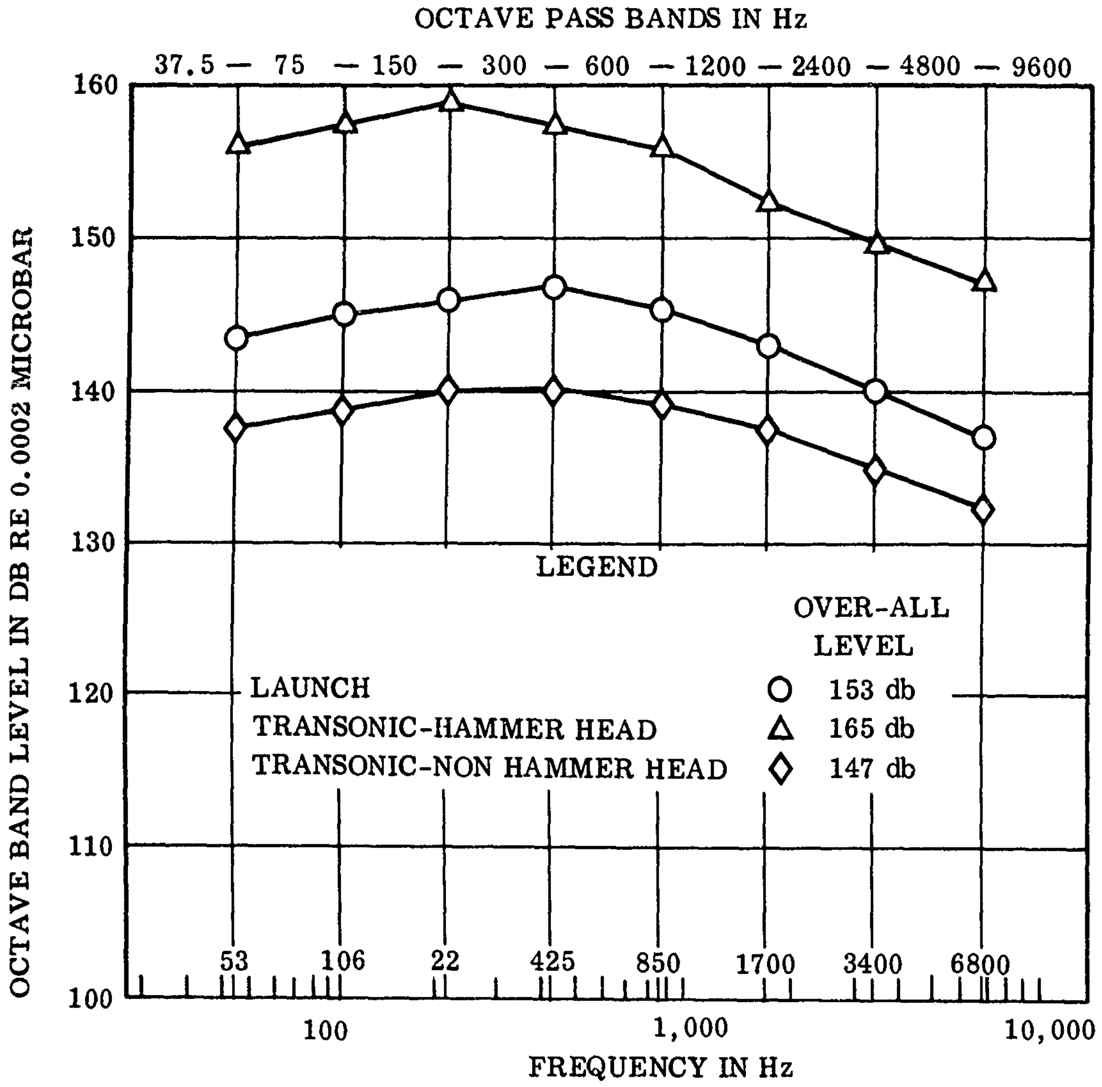


Figure 5-2. Atlas Acoustic Environment Above Station 502 (Primary Load)

5.1.5 Payload Stiffness Requirements. The fundamental frequency of the payload, when analyzed as a cantilevered system, should be greater than 20 Hz.

5.2 AUXILIARY PAYLOAD ENVIRONMENT. The environmental conditions encountered by an auxiliary payload mounted on the aft section of the E/F booster tank are due to thrust build-up and lift-off conditions, aerodynamic loads, longitudinal acceleration, propellant sloshing, acoustic noise, aerodynamic heating, booster tank

skin spring rates, and booster tank skin growth. These conditions were described in the preceding paragraphs, with the exception of aerodynamic heating, booster tank skin spring rates, and booster tank skin growth which are described in the following paragraphs.

5.2.1 Thrust Build-up and Lift-off Environment (Auxiliary Payload). Maximum conditions in these environments are:

a. Longitudinal acceleration: 1.0 ± 4.0 g's

b. Lateral acceleration: ± 4.0 g's

5.2.2 Maximum Aerodynamic Loads (Auxiliary Payload). Maximum aerodynamic loads encountered by side-mounted payload structures are caused by:

a. Aerodynamic drag due to a dynamic pressure of 1100 pounds per square foot at Mach 1.8.

b. Longitudinal acceleration of 2.5 g's.

c. Lateral loading due to an alpha q of 7500 degree pounds per square foot at Mach 1.8

d. Lateral acceleration depending on weight. (See Table 5-1.)

Table 5-1. Maximum Lateral Acceleration vs PEM Weight

Total PEM Weight (lb)	Maximum Lateral Acceleration (±g)
250	6.0
400	5.6
500	4.8
550	4.5
650	4.0
750	3.7
800	3.5
900	3.5

5.2.3 Maximum Longitudinal Acceleration (Auxiliary Payload). The maximum longitudinal acceleration that will be experienced by a side-mounted payload are:

a. Longitudinal acceleration: 10 g's

b. Lateral acceleration: 1 g

5.2.4 Acoustic Environment (Auxiliary Payload). The acoustic environment for a side-mounted auxiliary payload will be most severe during the launch phase of flight. The overall frequency and octave band acoustic levels for this condition are presented in Figure 5-3.

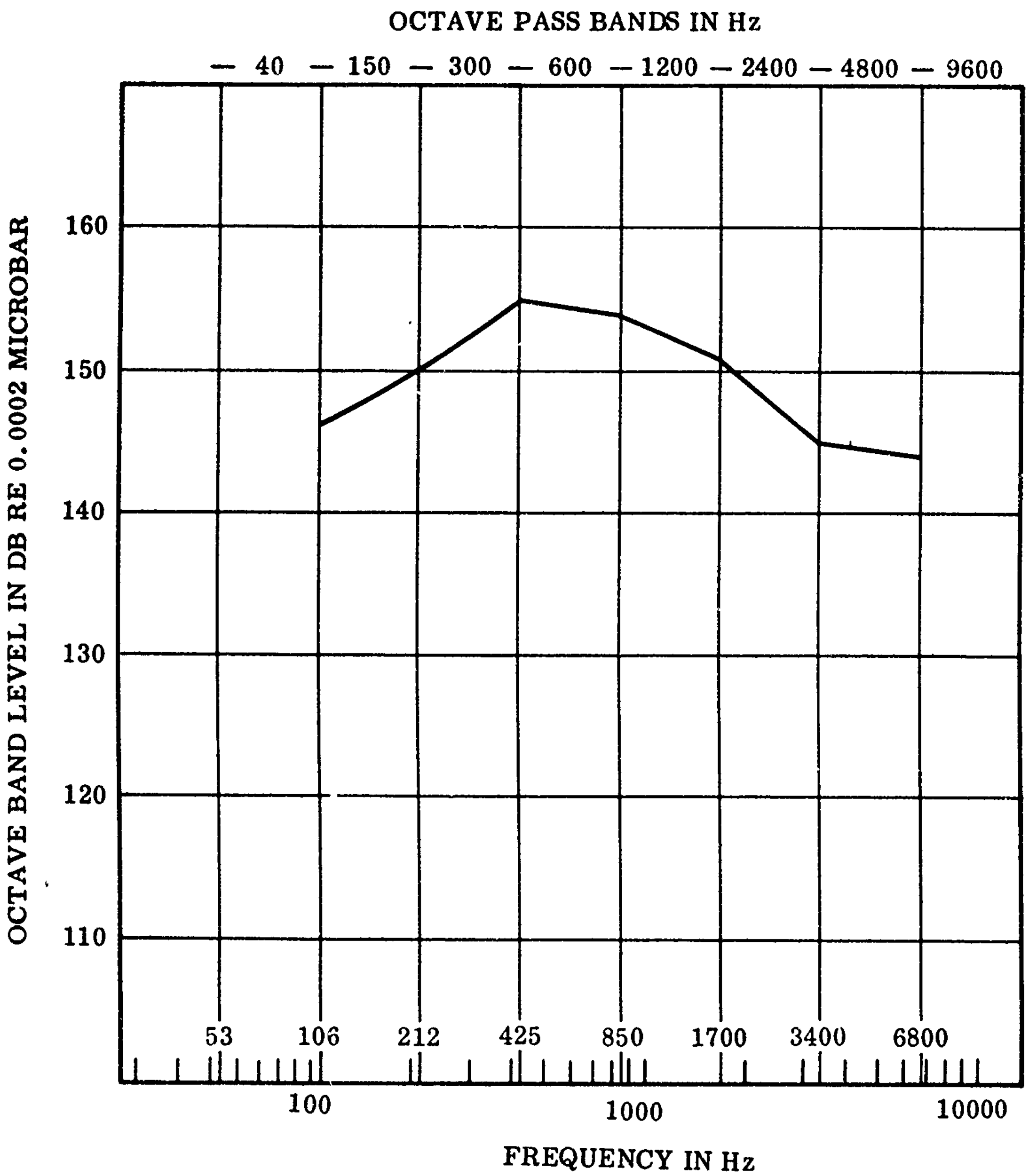


Figure 5-3. External Acoustic Environment for Auxiliary Payloads at Station 1090

5.2.5 Fuel Tank Spring Rates. The spring rates for fuel tank deflections due to loads normal to the skin surface are given as follows:

Time From Lift-off (sec)	Spring Rate (lb/in.)
0 to 138	55,000
200	48,000
280+	39,000

The variation of spring rates versus time is due to expected change in fuel tank pressure.

5.2.6 Booster Skin Circumferential and Longitudinal Growth. The lateral and longitudinal growth of the Atlas fuel tank within the pod attachments has been analytically determined to be as follows:

Circumferential Growth:	0.125 inch maximum (over span of 25.50 inches between fixed mounting points).
Longitudinal Growth:	0.154 inch maximum (over span of 80 inches).

These values include a 25-percent increase to account for an over-nominal fuel tank pressure which occasionally occurs.

Typical changes in length of the E/F Atlas between booster Stations 502 and 1269 and their causes are listed below:

Cause for Change	Extent of Change
Change LO_2 and Fuel Tank Stand-by Pressures to Flight Pressures	0.56 inch (Growth)
Add LO_2, Fuel and Payload	-0.11 inch (Contraction)
LO_2 Tank Temperature Effect Only	-1.28 inches (Contraction)
Total from Stand-by Pressures to Fueled and Flight Pressures	-0.83 inch (Contraction)
Horizontal Deflection Due to Adding LO_2, Fuel and Payload	0.21 inch (Horizontal)

5.3 VIBRATION TESTING OF COMPONENTS. Vibration test parameters for qualification of payload components for the powered phase of flight are provided below. These sinusoidal tests should be performed in each of three mutually perpendicular axes at a sweep rate of 4 minutes per octave. The levels which should be used are presented as a function of the weight of the particular component. These levels represent a best estimate for nose mounted payload where the components are conventionally mounted.

Component	Test Parameters
Complete payload.	
±2.5 g's vector (0 to peak)	10-500 Hz
50-100 pound components.	
±0.2 inches single amplitude	5-17.5 Hz
±6.0 g's vector	17.5-2000 Hz
0-50 pound components.	
±0.2 inches single amplitude	5-20 Hz
±8.0 g's vector	20-2000 Hz

5.4 DISPLACEMENT DUE TO GROUND WINDS. The displacement of the booster centerline due to ground winds varies with payload configuration. Tip displacements for the first mode of typical payloads is as follows:

	Tip Location Booster Station	Displacement (inches)		Wind Velocity (mph)
		E-F	F-F	
Cone/Cylinder				
22° Cone/48" Diameter	243	1.2	1.7	60
10° Cone/48" Diameter	146	1.5	1.8	60
Fairing System (Fig 2-10)	236	1.0		35
			1.4	30

These displacements involve static and oscillatory components. The frequency of the oscillatory components is usually less than 10 Hz.

E-F — Fuel tank fueled and at flight pressure - LO_2 tank empty and pressurized to 2.4 psi.

F-F — Both tanks full, fuel tank at flight pressure, LO_2 tank at 2.4 psi.

Wind Velocity — Peak anemometer reading when anemometer located 72' above ground level.

5.5 EVENT TIMES, ACCELERATION, THRUST, AND RATE DATA. Statistical longitudinal acceleration data, sustainer engine cut-off (SECO) to vernier engine cut-off (VECO) statistical timing variations, and statistical telemetered acceleration data for typical E and F Atlas booster flights are provided in Table 5-1. The post booster engine cut-off (BECO) and post SECO acceleration data represents smoothed axial acceleration data immediately following BECO and SECO, respectively.

5.6 AERODYNAMIC HEATING. Aerodynamic heating analyses are conducted by Convair on the Atlas tank skin and protuberances for specific mission requirements to assure adequate thermal protection. The analyses are based on a 3-sigma hot dispersion (or depressed trajectory) from a nominal trajectory.

Calculations are made considering angle of attack, material properties, and internal thermodynamics of the booster. If heating constraints are exceeded in the initial trajectory, other trajectories are evaluated until the heating constraint is met. In this way a final trajectory is determined. The selected trajectory is then used in the determination of additional heating of the Atlas tanks caused by auxiliary payloads. The auxiliary payloads induce flow separation and shockwave boundary layer interaction on the booster. Requirements are determined for the tank skin allowable temperature and other areas of the Atlas. In addition, the effect on the Atlas components is determined, with environmental conditions being determined for the payloads.

Aerodynamic heating analyses of the payload and auxiliary payloads are conducted by the payload contractor.

Table 5-1. Summary of Event Times and Axial Acceleration Levels for Atlas E/F Boosters

BOOSTER	EVENT TIMES (sec) T1 (sec)	BECO	SECO	T2
15F	124.74	124.82	298.13	314.95
83F	125.69	125.79	304.76	321.94
65E	125.76	125.86	298.47	315.73
62E	125.21	125.32	299.85	316.00
69E	126.65	126.76	305.27	322.50
109F	127.24	127.31	302.12	323.48
110F	125.06	125.17	300.15	323.40
36F	125.89	125.99	298.81	309.67*
	TIME INTERVAL (sec) T1-BECO	**BECO-SECO**	**SECO-T2**	
15F	0.08	173.3	16.82	
83F	0.10	179.0	17.18	
65E	0.10	172.6	17.26	
62E	0.1	174.5	16.15	
69E	0.11	178.5	17.23	
109F	0.07	174.8	21.36	
110F	0.11	175.0	23.25	
36F	0.10	172.8	10.86*	
	ACCELERATION LEVELS (g's) BECO	**POST BECO**	**SECO**	**POST SECO**
15F	7.1	1.4	6.2	0.1
83F	7.0	1.4	6.1	0.1
65E	6.9	1.3	6.1	0.1
62E	7.2	1.5	6.3	0.1
69E	7.1	1.4	5.9	0.1
109F	7.0	1.4	6.2	0.1
110F	-	-	-	-
36F	7.1	1.4	6.0	0.1

*Premature vernier cutoff by range safety.

NOTES:
1. T1 pod signal is time of issuance of BECO signal from autopilot programmer.
2. BECO and SECO refer to time and level of peak axial acceleration.
3. T2 pod signal is time of autopilot generated R/V separation signal. This event occurred at VECO + 6 seconds for these boosters.

Table 5-2. Dynamic Pressure History of Atlas E and F Predicted Nominal Trajectory, VAFB to Eniwetok (.97 PAF) (Nominal $\sim 18° \gamma$)

TIME AFTER STAGING (sec)	DYNAMIC PRESSURE, q (PSF)
0	14.17
0.25	13.63
0.75	12.60
1.75	10.75
3.75	7.71
5.75	5.45
7.75	3.75
9.75	2.52
11.75	1.71
13.75	1.01
15.75	0.62
17.75	0.38
19.75	0.23

Table 5-3. Dynamic Pressure History of Atlas E and F Predicted Severe Hot Trajectory, VAFB to Eniwetok (1.0185 PAF)

TIME AFTER STAGING (sec)	DYNAMIC PRESSURE, q (PSF)
0	24.64
0.25	23.93
0.75	22.46
2.75	17.37
6.75	10.08
10.75	5.57
14.75	2.92
18.75	1.40
22.75	0.62
26.75	0.28

SECTION 6
ALLOWABLE CENTER OF GRAVITY LIMITS

Booster center of gravity data must be considered by payload designers. This section gives basic c.g. data for boosters and discusses C.G. limitations imposed by the effects of flight environments on various booster/payload combinations.

6.1 ATLAS BOOSTER STABILITY AND CONTROL. Stability and control of the Atlas booster requires that the controlling rocket engines be able to produce suitable control forces and moments in response to signals generated by the autopilot loop. The maximum control force or moment that the engines can produce is a direct function of the maximum gimbal angle through which the engine may gimbal. This angle is established by design parameters and limited by mechanical stops. Other considerations such as unintended control system misalignments affect the available control angle.

The rocket engine gimbal angle requirements may be divided into two types: 1) dynamic angles or those control angles, induced by autopilot signals, required to overcome forces and moments that vary rapidly with powered flight time; and 2) static angles or control angles induced to balance the vehicle statically. These latter angles do not vary rapidly as a function of time.

The difference between the maximum available gimbal angle and the statistical sum of individual control angle requirements, resulting from these dynamic and static balance considerations will be the maximum engine control angle available to pass the line of action of the thrust vector through an offset booster center of gravity. This angle, by geometry, defines the maximum allowable lateral center of gravity travel as a function of longitudinal center of gravity position during powered flight.

For normal ballistic trajectories which have a maximum booster phase acceleration of 7.2 g's, a minimum of 2350 pounds and a maximum of 4500 pounds must be carried above Atlas station 502 with the operational autopilot. Payloads weighing less than 2350 pounds or more than 4500 pounds, or trajectories which cause a later BECO, can cause large divergent slosh oscillations. The minimum weight above Station 502 and the slosh sensitivity to payload weight and axial acceleration can be reduced by an autopilot modification. The addition of pods exceeding a total weight of 700 pounds may also cause a change in the weight requirement above Station 502.

6.2 EFFECT OF MAXIMUM CONDITIONS. Seven conditions of flight at which disturbances affecting the center of gravity would be the greatest are:

a. Maximum aerodynamic pressure (max q)

b. Booster engine cutoff (BECO)

c. Booster staging

d. Maximum center of gravity offset (peak C. G.)

e. Sustainer engine cutoff (SECO)

f. Maximum sloshing

g. Maximum acceleration loading prior to BECO.

6.2.1 Maximum Aerodynamic Pressure (Max q). The maximum aerodynamic pressure condition occurs at approximately 64 seconds of flight. For the Atlas, this condition occurs in the altitude region of 30,000 - 45,000 feet, where wind shear reversal and maximum wind gusts occur. As a result of the large angle of attack caused by the wind and of the high dynamic pressure, aerodynamic disturbances are most severe at this time.

6.2.2 Booster Engine Cutoff (BECO). The period during which the two booster engines decay in thrust just before staging is critical. During this period, adverse turning moments due to uneven thrust decay may be applied to the booster since the booster engines are nulled during the decay period. In order to reduce the magnitude of these moments, the lateral center of gravity position must be limited at the beginning of the booster thrust decay period.

6.2.3 Booster Staging. During and following the completion of the booster engines thrust decay, the sustainer engine is activated to maintain and reduce the magnitude of any shift in lateral center of gravity position. This is aided by nulling the servo pitch and yaw filter which eliminates the integration circuits, allowing quicker engine response for correction during the staging maneuver. To prevent excessive and rapid gimbaling of the sustainer engine upon completion of the staging maneuver, the lateral center of gravity must be limited at the beginning of the sustainer phase. Limiting the center of gravity decreases the possibility of structural damage to the sustainer engine actuators and thrust structure due to rapid movement of the engine required to overcome the staging transients.

6.2.4 Maximum Center of Gravity Offset (peak C. G.). The instant of flight when the center of gravity is displaced laterally at a maximum is the fourth critical point of flight. This instant occurs just prior to sustainer burnout when the LO_2 tank is near empty, but the LO_2 supply lines are full.

6.2.5 Sustainer Engine Cutoff (SECO). The fifth critical area occurs at sustainer cutoff (SECO). This occurs a few seconds after the peak C. G. offset when the engines

burn out due to minimum NPSH requirements. This condition is usually coincident with 6.2.4 since not all propellants are used.

6.2.6 Maximum Sloshing. Center of gravity limitations due to propellant sloshing are only significant for payload weights of 4000 to 4500 pounds located forward of booster Station 502. Detailed analyses for specific configurations can result in a combination of parameters and/or possible autopilot changes which could probably relax the longitudinal center of gravity requirements by as much as 50 inches for the heavier payloads.

6.2.7 Maximum Acceleration Loading Prior to BECO. The combination of maximum lateral acceleration due to propellant sloshing and the corresponding longitudinal acceleration, or maximum longitudinal acceleration with corresponding lateral acceleration can lead to a limitation on the center of gravity location for weight forward of booster Station 502 based on the present strength of the E/F Atlas at that station. Figure 6-1 presents center of gravity limitations at the time of maximum sloshing and Figure 6-2 presents center of gravity limitations at the time of BECO.

6.3 ALLOWABLE C.G. LIMITS. Figure 6-3 shows nominal allowable lateral center of gravity positions at vernier burnout for various payload weight combinations. The heavy dashed line represents the lateral center of gravity limitation as restrained by the available gimbal control angle. The following examples illustrate the use of Figure 6-3.

a. Example 1. Assume that a total payload weight of 4,000 pounds is to be launched. Assume that this payload is comprised of a typical 700-pound auxiliary payload located in booster Quadrant III, and that the remaining 3,300 pounds is comprised of a typical payload, adapter, and spacer located forward of booster Station 502. Under these conditions, the lateral center of gravity will be located at a position of -11.35 inches on the lateral or Y-axis shown by Point A on Figure 6-3. Figure 6-3 also shows that the lateral center of gravity is located in the region of lateral stability.

b. Example 2. As shown in Figure 6-3, auxiliary payload pod weights of 500 or 700 pounds can be mounted in booster Quadrant I and maintain stability, provided that the total payload weight exceeds approximately 1250 pounds as shown by the lower three solid curves. (Not a valid example for an operational autopilot.)

c. Example 3. As shown in Figure 6-3, a 500-pound auxiliary payload pod located in Quadrant III requires a total payload weight exceeding approximately 2800 pounds of which 2350 pounds (2800 minus 450) must be located forward of booster Station 502.

The longitudinal and vertical centers of gravity at minimum vernier burnout conditions for the E/F booster, shown in Figures 6-4 and 6-5 respectively, are not stability limited for side mounted pods but are affected by the 2350-lb minimum weight requirement, and are for reference only.

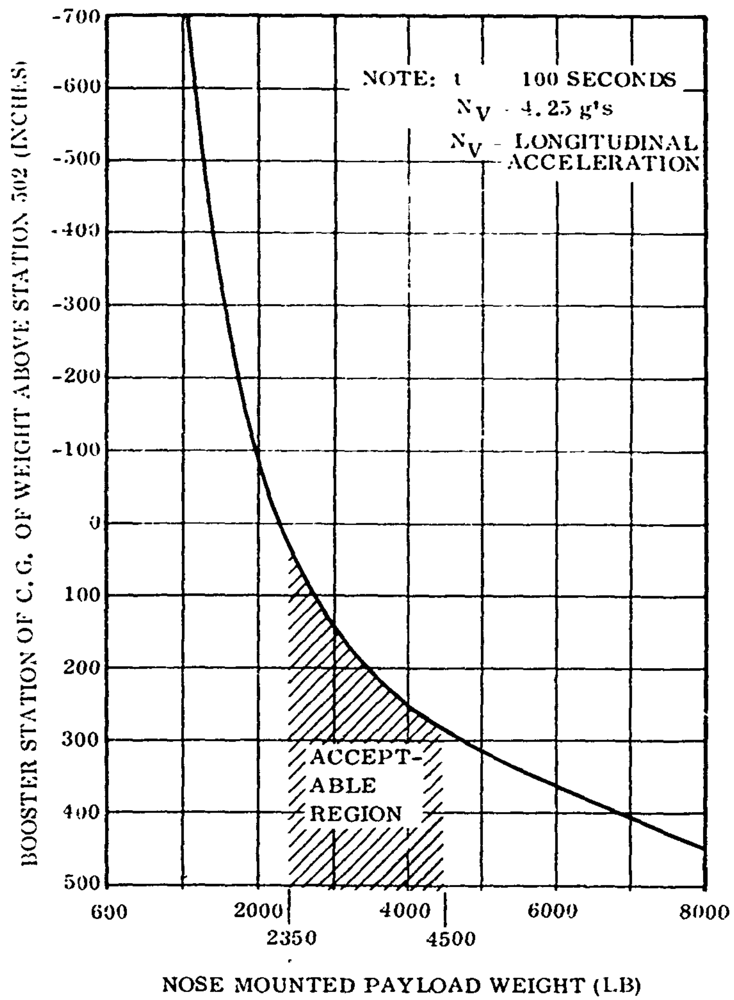


Figure 6-1. Center of Gravity Limitations Based on Loads at Maximum Sloshing

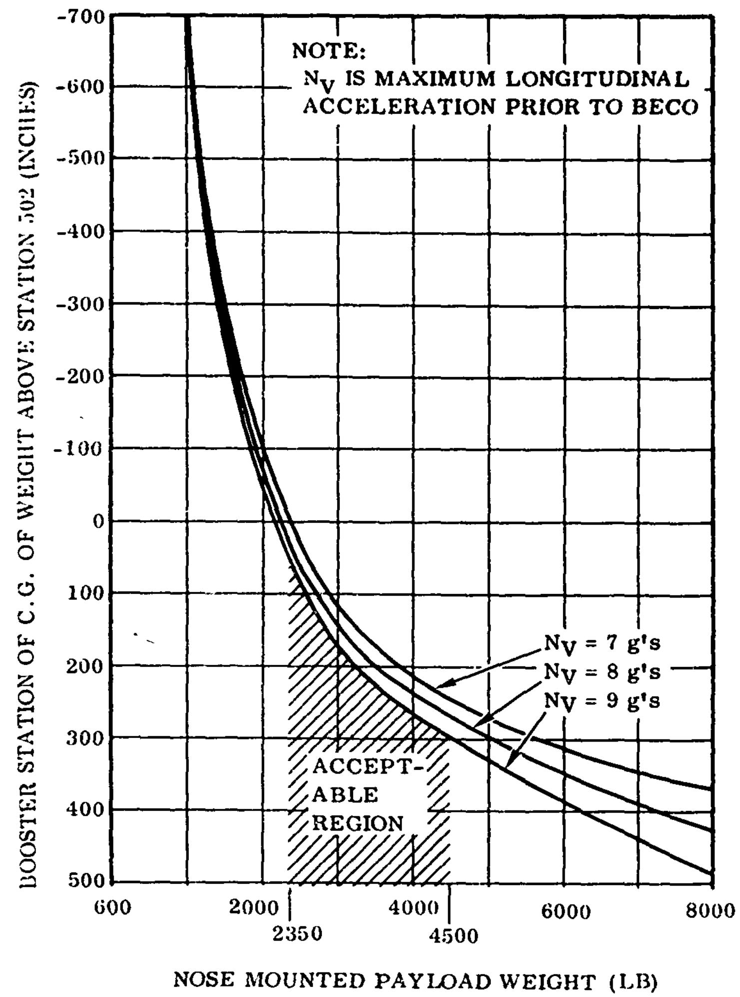


Figure 6-2. Center of Gravity Limitations Based on Loads Prior to BECO

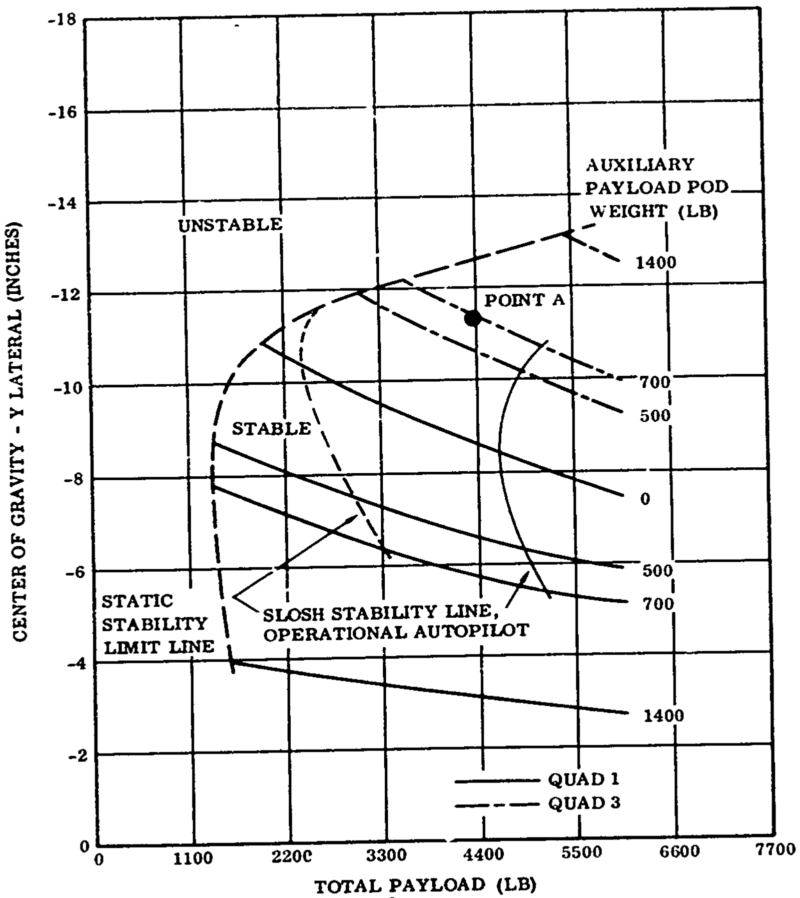


Figure 6-3. Total Payload Capability vs Center of Gravity - Lateral (At Minimum Burnout Conditions)

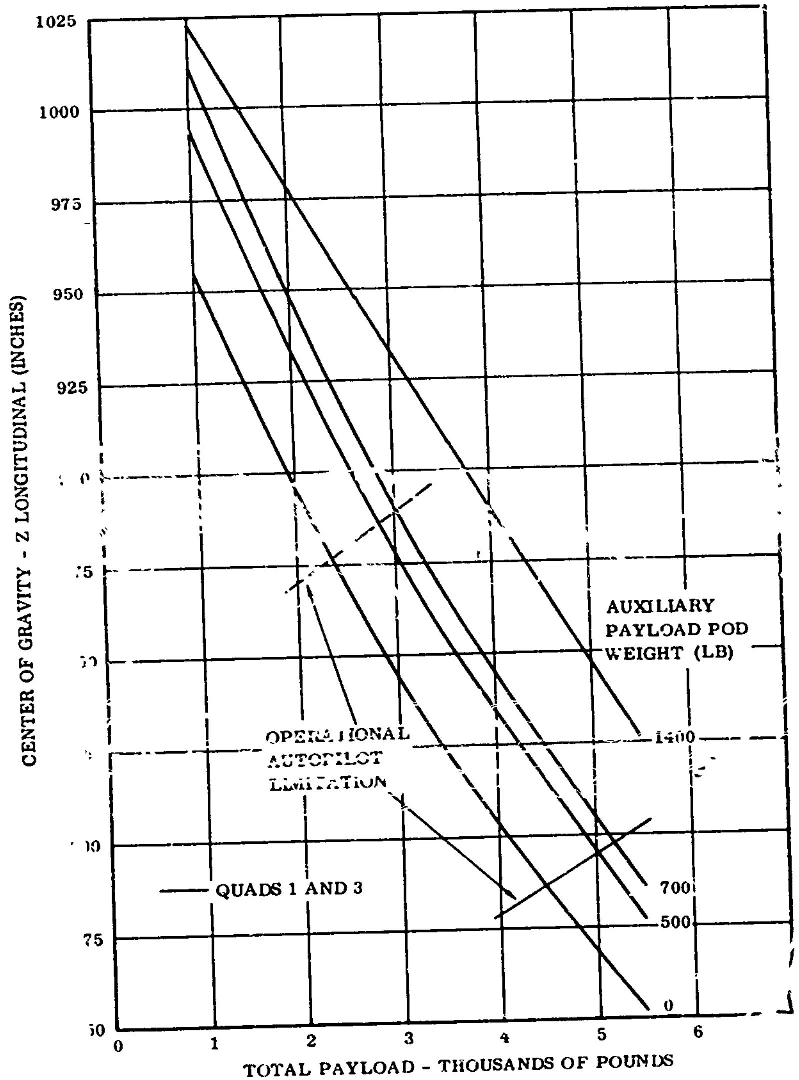


Figure 6-4. Total Payload Capability vs Center of Gravity - Longitudinal (At Minimum Burnout Conditions)

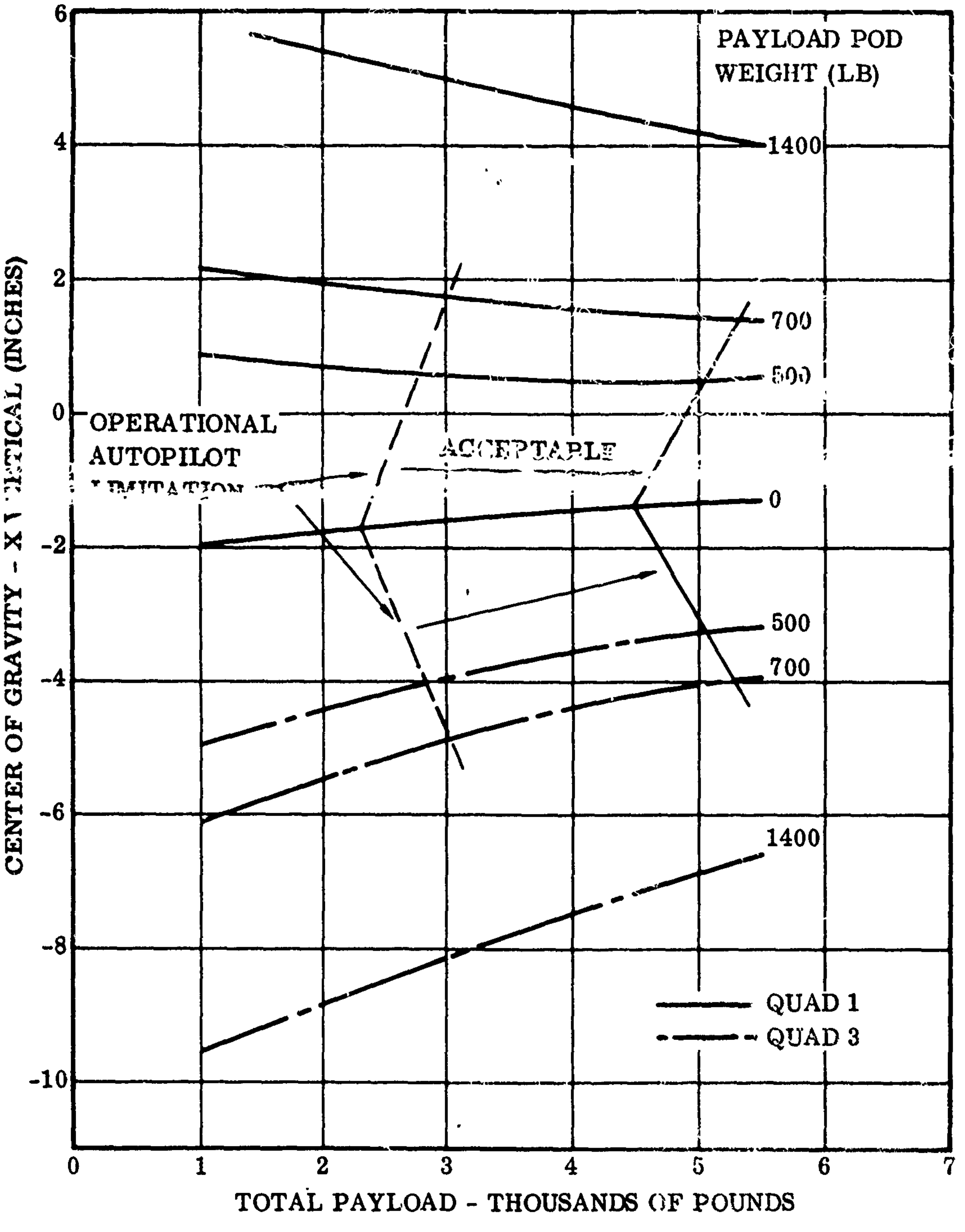


Figure 6-5. Total Payload Capability vs. Center of Gravity - Vertical (At Minimum Vernier Burnout Conditions)

SECTION 7
BOOSTER/PAYLOAD SEPARATION CRITERIA

Many factors must be considered to determine the effects of payload separation from Atlas E/F boosters. The following data identifies general constraints that payload users must be acquainted with to establish adequate payload design parameters.

7.1 BOOSTER/PAYLOAD SEPARATION CHARACTERISTICS. Payload separation from the E/F booster is affected by vernier engine thrust decay after vernier engine cutoff (VECO), and by booster roll, pitch and yaw rates after VECO.

7.1.1 Vernier Engine Thrust After VECO. The residual vernier engine thrust after VECO, presented in Figures 7-1 and 7-2, was derived from smoothed Arma guidance system telemetered acceleration data and from calculated flight test burnout weights.

Figure 7-1 presents the thrust from VECO minus 2 seconds to VECO plus 3 seconds and is common to the E/F booster.

Figure 7-2 presents the thrust for the E/F booster vernier engine beyond VECO plus 2 seconds. Figure 7-2 was used to compute the 3-sigma accelerations, velocities and distances for a "light vehicle" (11,000 lb) and a "heavy vehicle" (14,458 lb) if separation were to occur at VECO plus 1, 2, 3, 4, 5, or 6 seconds. The "trapezoidal rule" of numerical integration was employed.

The booster tank moves forward along the tank longitudinal axis at the time of re-entry vehicle separation. These incremental values, with an indication of the resultant final delta velocities, are plotted in Figures 7-3 and 7-4.

Figure 7-3 may be used to graphically determine the minimum separation distance between the booster tank and the re-entry vehicle versus time by superimposing the re-entry vehicle to booster tank differential movement imparted by a separation mechanism.

7.1.2 Booster Roll, Pitch and Yaw Rates After VECO. Residual tumbling rates and attitudes have been determined for previous booster flights. Tables 7-1 through 7-5 provide roll, pitch, and yaw data derived from the booster flights.

The arithmetic mean in Tables 7-1 through 7-5 is denoted by $\bar{x}$, and the $\pm 3\sigma$ values were grouped about $\bar{x}$; 68.27 percent of the cases are included between $\bar{x} - 1\sigma$ and $\bar{x} + 1\sigma$, and 99.73 percent of the cases are included between $\bar{x} - 3\sigma$ and $\bar{x} + 3\sigma$.

The booster turning rate sign convention is provided in Figure 7-5.

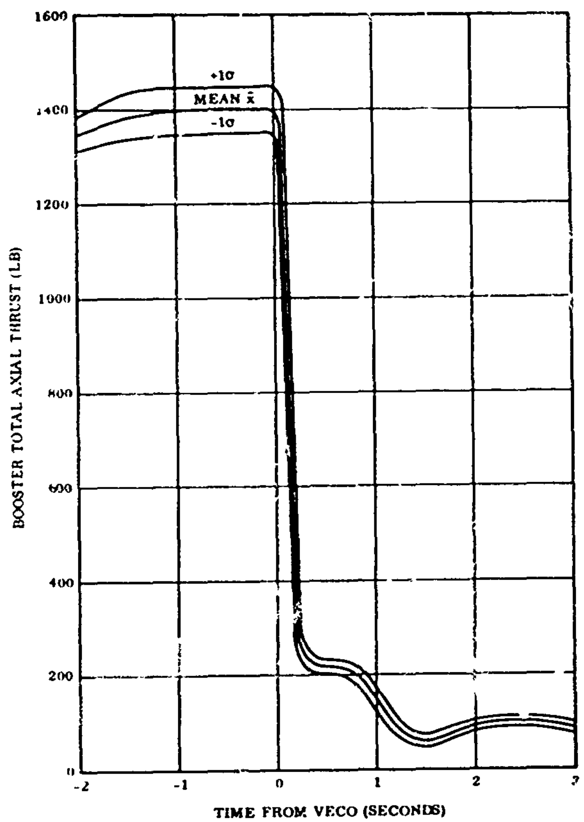


Figure 7-1. Atlas Vernier Engine Thrust After Vernier Engine Cutoff - Hypergolic

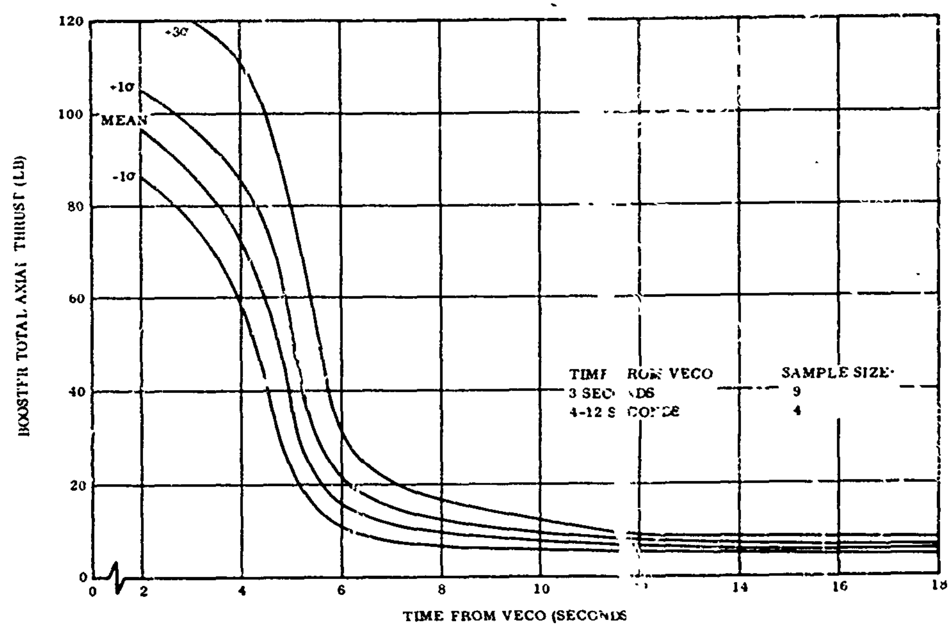


Figure 7-2. Atlas Vernier Engine Thrust After Vernier Engine Cutoff - Hypergolic Start Verniers, E and F Boosters

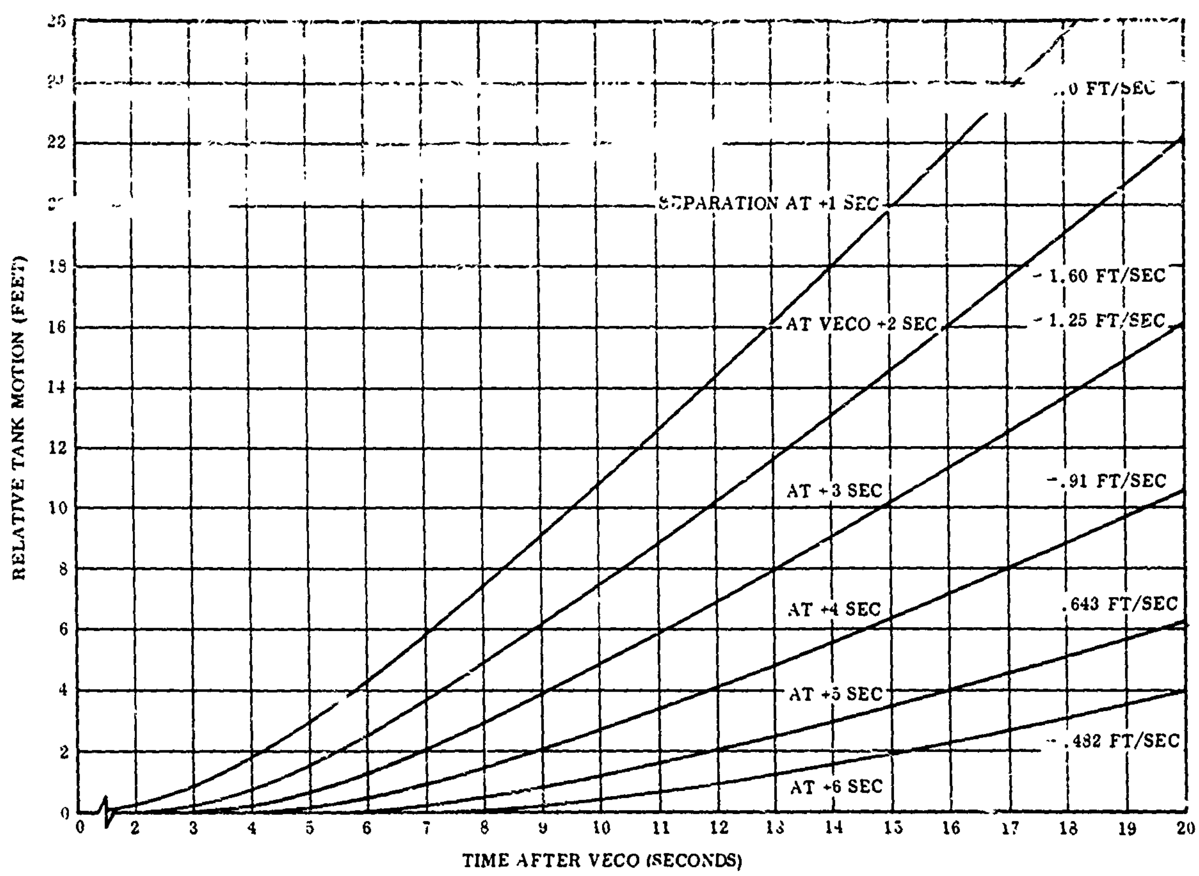


Figure 7-3. Relative Motion of Tank Due to 3-Sigma Residual Vernier Thrust (With Hypergolic Start Verniers), E and F Boosters, "Light Vehicle" (11, 000 lb)

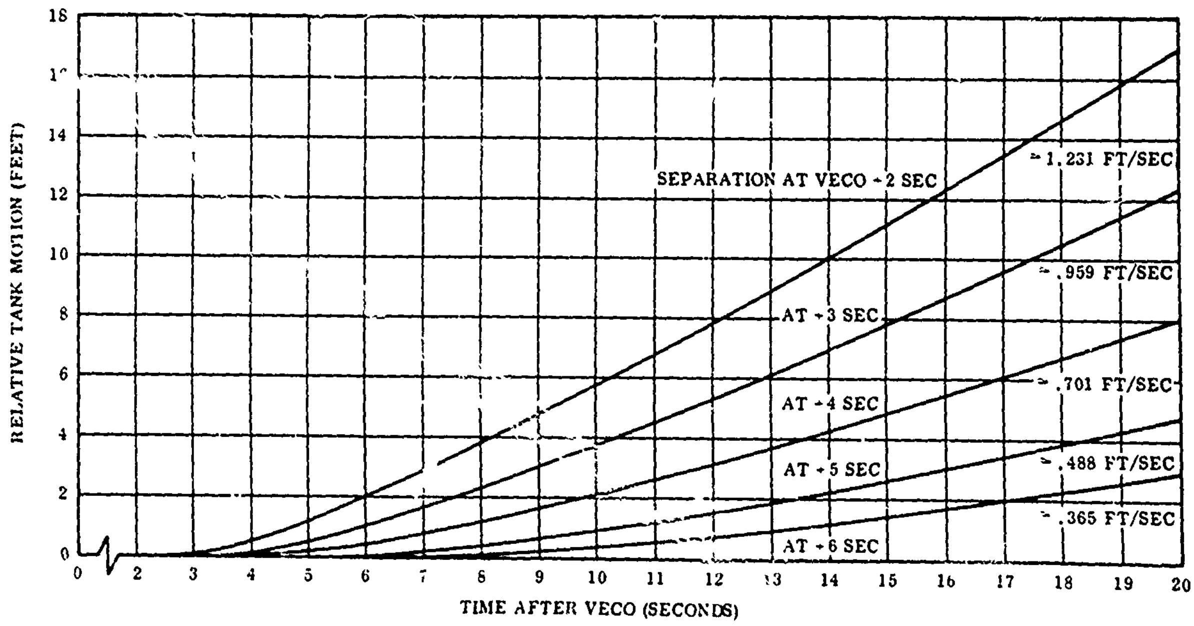
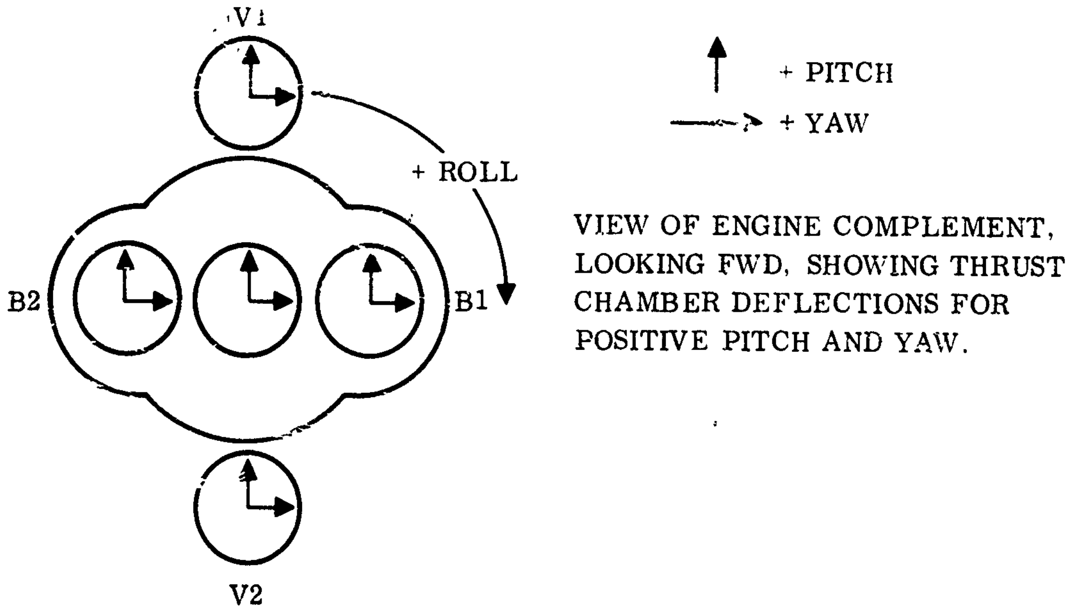


Figure 7-4. Relative Motion of Tank Due to 3-Sigma Residual Vernier Thrust (With Hypergolic Start Verniers). E and F Boosters. "Heavy Vehicle" (14, 458 lb)



NOTES:

1. WITH THE BOOSTER FLYING IN A NORMAL HORIZONTAL CONFIGURATION, THE FOLLOWING POLARITY CONVENTIONS APPLY:

PITCH:	POSITIVE:	NOSE UP.
YAW:	POSITIVE:	NOSE RIGHT.
ROLL:	POSITIVE:	CLOCKWISE, VIEWED LOOKING FORWARD.

2. ENGINE THRUST VECTOR MOTIONS TO PROVIDE PITCH AND YAW ARE SHOWN BY ARROWS. POSITIVE ROLL IS OBTAINED BY DEFLECTING BOOSTER 1 FOR POSITIVE PITCH AND BOOSTER 2 FOR NEGATIVE PITCH, OR BY DEFLECTING VERNIER 1 FOR NEGATIVE YAW AND VERNIER 2 FOR POSITIVE YAW.
3. WHEN A POSITIVE (IN PHASE WITH PHASE A) GUIDANCE PITCH, YAW, OR ROLL COMMAND IS SENT TO THE FLIGHT CONTROL SYSTEM, THE ENGINES MOVE TOWARDS A POSITIVE PITCH, YAW, OR ROLL DIRECTION, RESPECTIVELY.
4. WHEN A NEGATIVE (180 DEGREES OUT OF PHASE WITH PHASE A) GUIDANCE PITCH, YAW, OR ROLL COMMAND IS SENT TO THE FLIGHT CONTROL SYSTEM, THE ENGINES MOVE TOWARDS A NEGATIVE PITCH, YAW, OR ROLL DIRECTION, RESPECTIVELY.

Figure 7-5. Engine Movement Polarity

7.2 BOOSTER RETROROCKET SYSTEM. The baseline E/F booster contains provisions for two Atlas booster retrorockets located in the B-2 pod, two Thor retrorockets located in the vernier engine fairings and the HIRS. Each mission must specify which, if any, of these systems will be utilized.

A delta velocity of approximately 2.5 ft/sec can be achieved with the two Atlas retrorockets and approximately 6 ft/sec when both Thor and Atlas retrorockets are employed. Booster turning rate following simultaneous firing of the Thor and Atlas retrorockets is provided in Table 7-6. The estimated accuracy of the turning rate values is ±0.1 degree per second. Tables 7-7 and 7-8 provide leading particulars of the Atlas and Thor retrorockets.

Booster turning rates resulting from a retrofire sequence from between VECO and approximately VECO + 8 seconds may be partially damped by residual vernier engine thrust.

Table 7-1. E/F Boosters Roll, Pitch and Yaw Rates After VECO (Degrees/Second)

	$\bar{x}$	1σ	3σ	$\bar{x}+3\sigma$	$\bar{x}-3\sigma$	
After VECO:						
Roll	0.2094	0.2364	0.7092	0.9186	-0.4998	(+ CW)
Pitch	-0.0379	0.2385	0.6855	+0.6476	-0.7234	(+ up)
Yaw	-0.0334	0.3030	0.9090	+0.8756	-0.9424	(+ right)
After R/V Separation:						
Roll	0.0453	0.5694	1.7082	+1.7535	-1.6629	
Pitch	+0.0162	0.1483	0.4449	+0.4611	-0.4287	
Yaw	+0.0284	0.2760	0.8280	+0.8564	-0.7996	

Table 7-2. E/F Boosters 3-Sigma Roll Angles After VECO

TIME AFTER VECO (sec)	STARTING FROM VECO				STARTING FROM R/V SEPARATION			
	3σ (deg)	$\bar{x}-3\sigma$ (deg)	$\bar{x}$ (deg)	$\bar{x}+3\sigma$ (deg)	3σ (deg)	$\bar{x}-3\sigma$ (deg)	$\bar{x}$ (deg)	$\bar{x}+3\sigma$ (deg)
0	0.00	0.00	0.00	0.00				
1	0.71	-0.50	0.21	0.92				
2	1.42	-1.00	0.42	1.84				
3	2.13	-1.50	0.63	2.76				
4	2.84	-2.00	0.84	3.67				
5	3.55	-2.50	1.55	4.60				
6	4.25	-3.00	1.25	5.50	0.00	0.00	0.00	0.00
7	5.96	-4.66	1.30	7.26	1.71	-1.66	0.05	1.76
8	7.32	-6.03	1.29	8.61	3.07	-3.04	0.03	3.10
9	8.68	-7.41	1.27	9.95	4.43	-4.41	0.02	4.45
10	10.04	-8.78	1.26	11.30	5.78	-5.78	0.0	5.78
11	11.40	-10.16	1.24	12.64	7.14	-7.16	-0.02	7.12
12	12.76	-11.53	1.23	13.99	8.50	-8.53	-0.03	8.47
13	14.12	-12.91	1.21	15.33	9.86	-9.91	-0.05	9.81
14	15.48	-14.28	1.20	16.68	11.22	-11.28	-0.06	11.16
15	16.85	-15.65	1.20	18.05	12.58	-12.65	-0.07	12.51
16	18.19	-17.03	1.16	19.35	13.94	-14.03	-0.09	13.85
17	19.55	-18.40	1.15	20.70	15.30	-15.40	-0.10	15.20
18	20.91	-19.78	1.13	22.04	16.66	-16.78	-0.12	16.54
19	22.27	-21.15	1.12	23.39	18.02	-18.15	-0.13	17.88
20	23.63	-22.52	1.11	24.74	19.37	-19.53	-0.16	19.21
21	24.99	-23.90	1.09	26.08	20.73	-20.90	-0.17	20.56
22	26.35	-25.27	1.08	27.43	22.09	-22.27	-0.18	21.91
23	27.71	-26.65	1.06	28.77	23.45	-23.65	-0.20	23.25
24	29.07	-28.02	1.05	30.12	24.81	-25.02	-0.21	24.60

Table 7-3. E/F Boosters 3-Sigma Pitch Angles After VECO

TIME AFTER VECO (sec)	STARTING FROM VECO				STARTING FROM R/V SEPARATION			
	3σ (deg)	x̄+3σ (deg)	x̄ (deg)	x̄-3σ (deg)	3σ (deg)	x̄+3σ (deg)	x̄ (deg)	x̄-3σ (deg)
0	0.00	0.00	0.00	0.00				
1	0.68	+0.65	-0.03	-0.71				
2	1.37	+1.29	-0.08	-1.45				
3	2.06	+1.94	-0.12	-2.18				
4	2.74	+2.59	-0.15	-2.89				
5	3.43	+3.24	-0.19	-3.62				
6	4.11	+3.88	-0.23	-4.34	0.00	0.00	0.00	0.00
7	4.56	+4.35	-0.21	-4.77	0.44	+0.46	+0.02	-0.42
8	5.30	+5.16	-0.14	-5.44	1.19	+1.27	+0.08	-1.11
9	6.05	+5.98	-0.07	-6.12	1.94	+2.09	+0.15	-1.75
10	6.80	+6.79	-0.01	-6.81	2.68	+2.90	+0.22	-2.46
11	7.54	+7.60	+0.06	-7.48	3.43	+3.72	+0.29	-3.14
12	8.29	+8.42	+0.13	-8.16	4.18	+4.53	+0.35	-3.83
13	9.04	+9.23	+0.19	-8.85	4.92	+5.35	+0.43	-4.49
14	9.78	+10.05	+0.27	-9.51	5.67	+6.16	+0.49	-5.18
15	10.53	+10.86	+0.33	-10.20	6.42	+6.98	+0.56	-5.86
16	11.27	+11.68	+0.41	-10.86	7.16	+7.79	+0.63	-6.53
17	12.02	+12.49	+0.47	-11.55	7.91	+8.61	+0.70	-7.21
18	12.77	+13.31	+0.54	-12.23	8.65	+9.42	+0.77	-7.88
19	13.51	+14.12	+0.61	-12.90	9.40	-10.24	+0.84	-8.56
20	14.26	+14.94	+0.68	-13.58	10.15	-11.05	+0.95	-9.20
21	15.00	+15.75	+0.75	-14.25	10.89	+11.87	+0.98	-9.91
22	15.75	+16.57	+0.82	-14.93	11.64	+12.68	+1.04	-10.60
23	16.50	+17.38	+0.88	-15.62	12.39	+13.50	+1.11	-11.28
24	17.24	+18.20	+0.96	-16.28	13.13	+14.31	+1.18	-11.95

Table 7-4. E/F Boosters 3-Sigma Yaw Angles After VECO

TIME AFTER VECO (sec)	STARTING FROM VECO				STARTING FROM R/V SEPARATION			
	3σ (deg)	x̄+3σ (deg)	x̄ (deg)	x̄−3σ (deg)	3σ (deg)	x̄+3σ (deg)	x̄ (deg)	x̄−3σ (deg)
0	0.00	0.00	0.00	0.00				
1	0.91	+0.87	-0.04	-0.95				
2	1.82	+1.75	-0.07	-1.89				
3	2.73	+2.63	-0.10	-2.83				
4	3.64	+3.50	-0.14	-3.78				
5	4.54	+4.38	-0.16	-4.70				
6	5.45	+5.25	-0.20	-5.65	0.00	0.00	0.00	0.00
7	6.28	+6.11	-0.16	-6.44	0.83	+0.86	+0.03	-0.80
8	7.68	+7.71	+0.03	-7.65	2.22	+2.45	+0.23	-1.99
9	9.07	+9.30	+0.23	-8.84	3.62	+4.05	+0.43	-3.19
10	10.47	+10.90	+0.43	-10.04	5.01	+5.65	+0.54	-4.37
11	11.86	+12.50	+0.64	-11.22	6.41	+7.25	+0.84	-5.57
12	13.26	+14.10	+0.84	-12.42	7.80	+8.84	+1.04	-6.76
13	14.65	+15.70	+0.05	-13.60	9.20	+10.44	+1.24	-7.96
14	16.04	+17.29	+0.25	-14.79	10.59	+12.04	+1.45	-9.14
15	17.44	+18.89	+0.45	-15.99	11.99	+13.64	+1.65	-10.34
16	18.83	+20.49	+0.66	-17.17	13.38	+15.23	+1.85	-11.53
17	20.23	+22.10	+1.87	-18.36	14.78	+16.83	+2.05	-12.73
18	21.63	+23.68	+2.05	-19.58	16.17	+18.43	+2.26	-13.91
19	23.02	+25.28	+2.26	-20.76	17.57	+20.03	+2.46	-15.11
20	24.42	+26.88	+2.46	-21.96	18.96	+21.63	+2.67	-16.29
21	25.81	+28.48	+2.67	-23.14	20.36	+23.22	+2.86	-17.50
22	27.21	+30.07	+2.86	-24.35	21.75	+24.82	+3.07	-18.68
23	28.60	+31.67	+3.07	-25.53	23.15	+26.42	+3.27	-19.88
24	30.00	+33.27	+3.27	-26.73	24.54	+28.02	+3.48	-21.06

Table 7-5. E/F Boosters Roll, Pitch and Yaw Rates After Retro-rocket Firing (Degrees/Second)

ATTITUDE	$\bar{x}$	1σ	3σ	$\bar{x}+3\sigma$	$\bar{x}-3\sigma$	
After 2 Booster Retro-rockets (Decoys Fired):						
Roll	1.4890	0.9107	2.7321	4.2211	-1.2431	(+ CW)
Pitch	-0.0378	0.1305	0.3915	+0.3537	-0.4293	(+ up)
Yaw	-0.3634	0.8037	2.4111	+2.0477	-2.7745	(+ right)

Table 7-6. Atlas E/F Angular Rates Following Firing of Atlas/Thor Retrorockets (Degrees/Second)

ATTITUDE	$\bar{x}$	3σ	$\bar{x}+3\sigma$	$\bar{x}-3\sigma$
Roll	-4.7	15.4	10.7	-20.1
Pitch	-0.3	2.0	+1.7	-2.3
Yaw	+0.6	4.7	4.1	-5.3

Table 7-7. Atlas Retrorocket Characteristics

Manufacturer: Rocket Power, Inc., Mfg. P/N 2547-A	
Average chamber pressure	@ 70° F = 735 psia @ -40° F = 644 psia @ 200° F = 835 psia
Average thrust in vacuum	@ 70° F = 541 lb @ -40° F = 448 lb @ 200° F = 614 lb
Total impulse in vacuum	@ 70° F = 497 lb/sec @ -40° F = 478 lb/sec @ 200° F = 497 lb/sec
Burn time	@ 70° F = 0.92 sec @ -40° F = 1.07 sec @ 200° F = 0.81 sec
Specific impulse in vacuum	@ 70° F = 230 sec
Nozzle area ratio	= 7.22
Nozzle semi-divergence angle	= 8.35°
Nozzle configuration	= Conical
Ratio of specific heats	= 1.23
Total temperature	= 4780° F
Nozzle throat diameter	= 0.763 in.
Location: Two units per Atlas F booster; located in the B2 pod Quadrants II and III with nozzle exit at approximately station 899.33. Retrorocket axis is canted at 15 degrees 35 minutes from booster longitudinal axis.	

Table 7-8. Thor Retrorocket Characteristics

Manufacturer: Atlantic Research Corporation, Mfg. P/N DM-18	
Average chamber pressure	@ 70° F = 1800 psia @ -75° F = 1100 psia @ 175° F = 2480 psia
Average thrust in vacuum	@ 70° F = 855 lb @ -75° F = 515 lb @ 175° F = 1120 lb
Total impulse in vacuum	@ 70° F = 1185 lb/sec @ -75° F = 1185 lb/sec @ 175° F = 1255 lb/sec
Burn time	@ 70° F = 1.385 sec @ -75° F = 2.3 sec @ 175° F = 1.12 sec
Specific impulse in vacuum	@ 70° F = 218 sec
Nozzle area ratio	= 18
Nozzle semi-divergence angle	= 10°
Nozzle configuration	= Conical
Ratio of specific heats	= 1.25
Total temperature	= 2405° K
Nozzle throat diameter	= 0.597 in.
Location: Two units per booster; one mounted just forward of each vernier engine pod such that retrorocket axis is parallel with booster longitudinal axis. The retrorocket axis is approximately 8.6 inches from the booster skin. Nozzle exit plane is approximately at station 1036. One unit is mounted on the fuel tank apex when the HIRS is utilized.	

SECTION 8

HIGH IMPULSE RETROROCKET SYSTEM PERFORMANCE

The High Impulse Retrorocket System (HIRS) is used to maneuver the booster so that at a re-entry altitude of 300,000 feet, one of the following two conditions exist:

a. A separation of at least 50,000 feet exists between the re-entry vehicle and the booster. or

b. A minimum cone angle of five degrees exists between the terminal radar lines of sight to the re-entry vehicle and to the booster.

The maneuver executed by the HIRS allows extended radar look angles between the sustainer stage and the payload so that the downrange radar will see only the payload at re-entry.

The HIRS consists of an adapter assembly to mate the payload and booster tank, two retrorockets with a total axial impulse of 17,200 lb/sec (for 2.8 second), a pitch rocket, a retrorocket positioning mechanism, a control unit to sense rotation and activate the rockets, and electrical power and signal cabling. All of the HIRS components are housed in the adapter except the pitch rocket which is mounted at the apex of the booster fuel tank. See Figure 8-1.

The pitch rocket is fired shortly after VECO to pitch the nose of the booster down. The HIRS rockets are then positioned and fired by command from the attitude control system when the gyros sense the proper angular rotation of the booster tank section. The resultant thrust places the booster in a trajectory behind and above the payload (Figure 8-2). A typical sequence is as follows:

a. Payload separates at VECO + six seconds.

b. Decoys ejected, if installed, at payload separation + t, where t is mission and decoy type dependent.

c. Pitch rocket fired at payload separation + 10 seconds.

d. Retrorockets positioned at separation signal + 11 seconds.

e. HIRS retrorockets fired when pitch or combined pitch-yaw angle is 110° ± 11.5% or 145° ± 11.5%.

The application of the HIRS to a specific booster and flight requires an analysis of the HIRS maneuver to assure optimum timing of events and an adequate separation distance between the rotating tank and the re-entry vehicle immediately following HIRS retro-

rocket firing. A nominal tank rotation setting of either 110° or 145° will be determined by the separation distance and the relative attitude between the tank and the re-entry vehicle.

The "fire HIRS pitch rocket" signal is an adjustable time initiated 8 to 30 seconds after re-entry vehicle separation. The tolerance of the timer is ±2 percent of the time set.

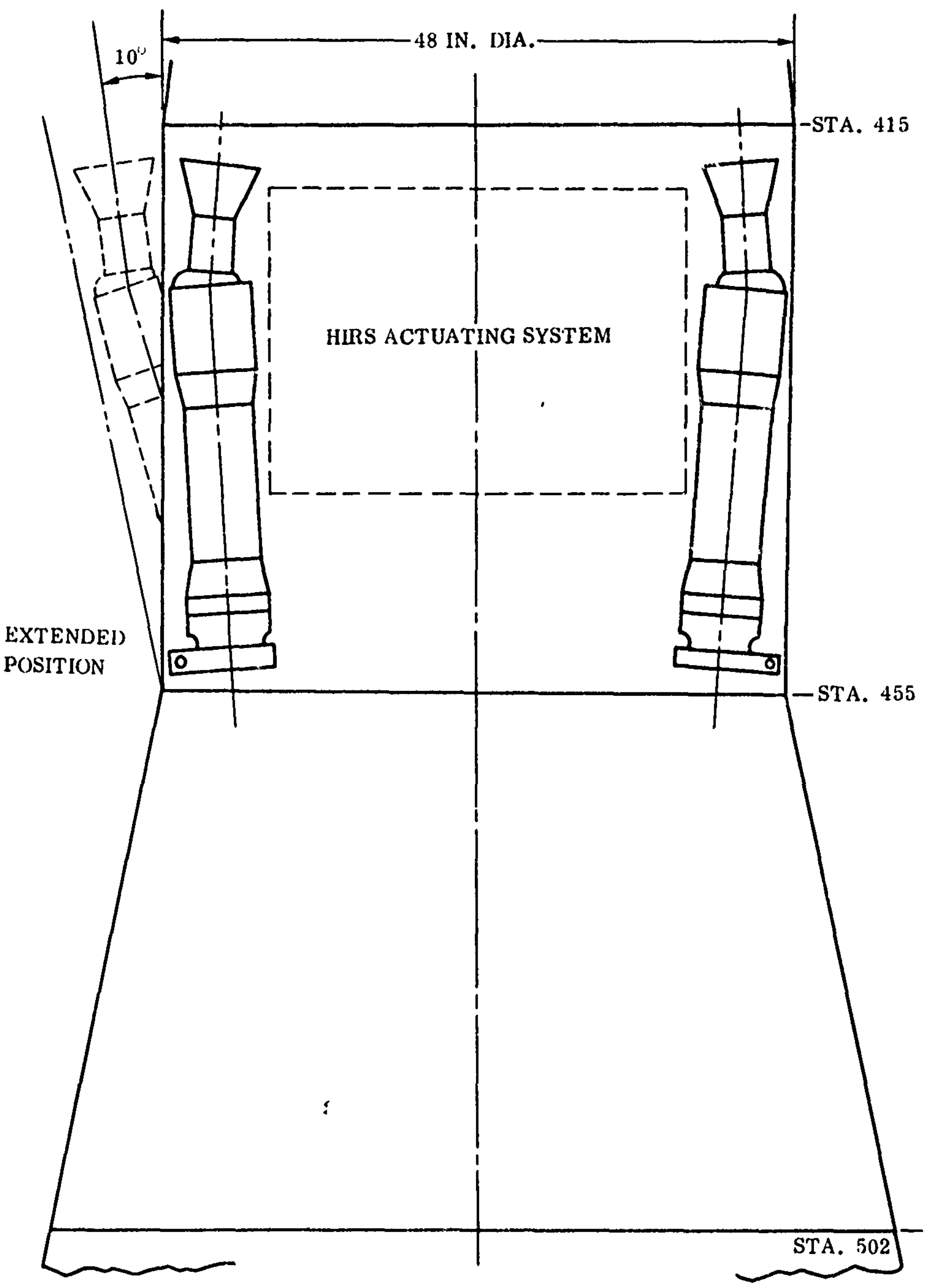


Figure 8-1. High Impulse Retrorocket System

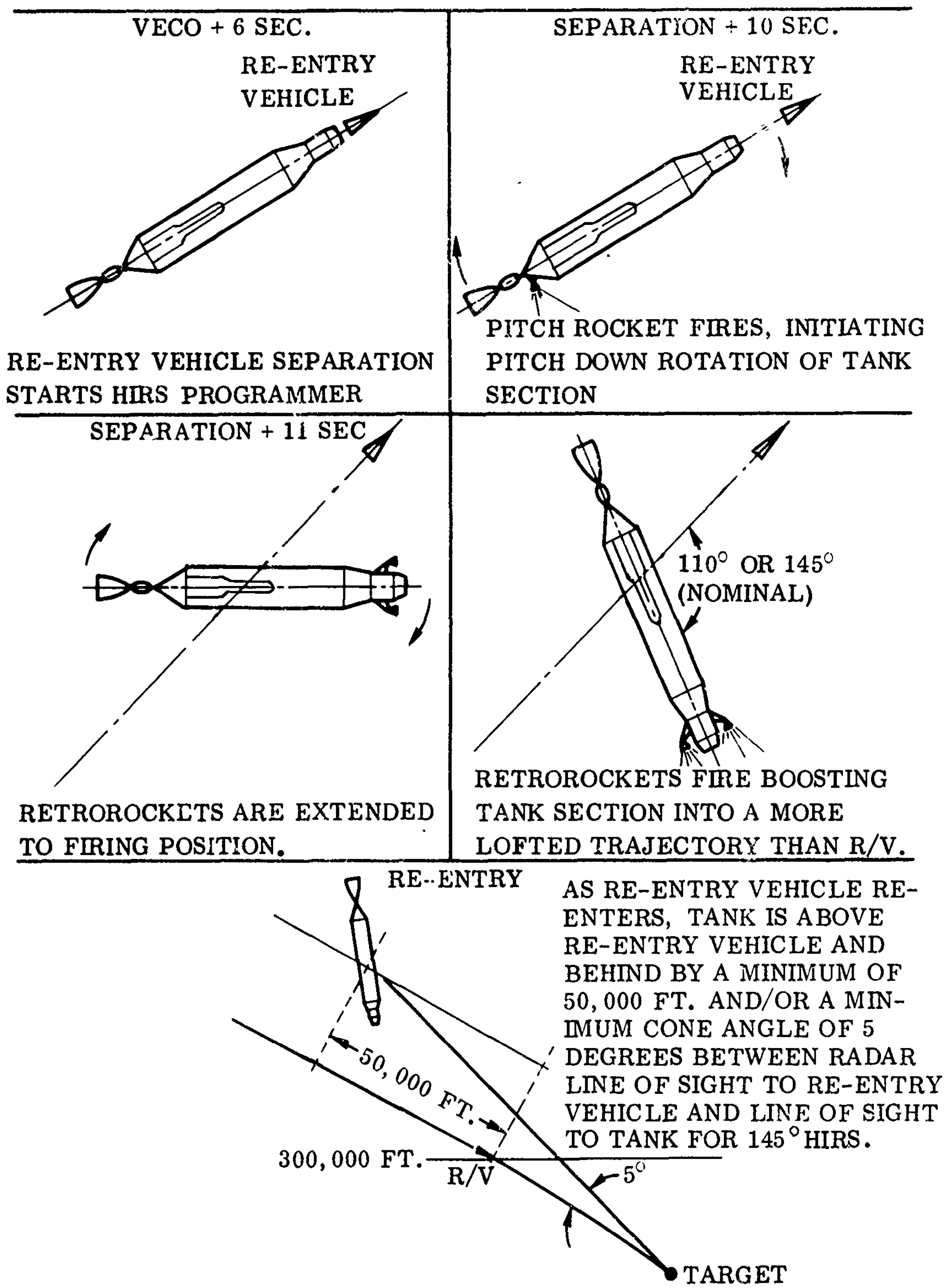


Figure 8-2. Typical Sequence of HIRS Events

SECTION 9
INSTRUMENTATION

The Atlas E/F boosters are equipped with extensive instrumentation subsystems which are linked to ground receiving stations via standard FM-FM multiplex telemeter transmitters. These systems are capable of measuring functions on continuous or commutated channels. Numerous flight parameters are instrumented in the booster autopilot system and in the guidance system in addition to all other booster systems to obtain data used for postflight analyses.

Convair evaluates and documents overall system performance within five days after launch. This report, available upon request, contains the sequence of flight events including engine cutoff event times, signals to the payload interface, payload separation, retrorocket fire and range safety commands. On selected flights a comprehensive flight evaluation report is prepared and is available 45 days after launch.

This section describes the Atlas E/F telemeter systems, identifies routinely measured functions of the booster and guidance systems, and defines instrumentation space available for payload contractor use. It also identifies availability of space to install additional booster telemeters for payload use up to payload separation during flight.

9.1 ATLAS E/F BOOSTER TELEMETERS. The standard E/F Atlas booster is equipped with two telemeters: the Analog Signal Converter and Telemeter (ASCAT), and the ABRES Instrumentation and Range Safety System (AIRSS).

The ASCAT is used exclusively to transmit Arma guidance data indicating booster accelerations, guidance computer calculations and commands, and platform angular positions during flight. The system employs standard FM/FM techniques to transmit data continuously.

The AIRSS is used to transmit all booster systems data except Arma guidance. When General Electric Radio Command guidance is installed in lieu of Arma guidance the guidance data is transmitted via the AIRSS. The AIRSS is presently modified to provide 13 continuous and 5 commutated data channels. Other commutated channels may be added. Electronic commutators of high reliability are utilized together with a modular signal conditioner and flexible measurement and signal patching capability. Additional measurements or re-channelizing of measurements is possible.

Approximately 126 measurements normally monitor guidance and booster systems. Typical functions of possible interest to payload contractors are described in paragraphs 9.1.1 through 9.1.9. Pertinent data is available in the preliminary report described above; and more detailed information can be made available if requested.

9.1.1 Range Safety Functions. These measurements indicate that the booster has received commands from the Range Safety Officer to stop the engines and/or to destroy itself. The commands will be sent only if the booster approaches or exceeds the range safety boundary for the intended trajectory. Payload contractors have made use of these range safety commands to inhibit some functions in the payload. This is accomplished by sending the command to the payload via special internal wiring at the same time it is sent to the booster. Typical measurements that monitor these functions are as follows:

a. Booster Destruct Signal, Receiver No. 1.

b. Booster Destruct Signal, Receiver No. 2.

c. No. 2 RSC AGC.

d. No. 1 RSC AGC.

e. Manual Fuel Cutoff (All Fuel Cutoff).

f. Automatic Fuel Cutoff (SECO).

9.1.2 Arma Guidance Functions. The Arma guidance measurement (ASCAT telemetry) which yield accurate acceleration data along the X, Y, and Z axes are as follows:

a. Accelerometer XF1.

b. Accelerometer XF2.

c. Accelerometer YF1.

d. Accelerometer ZF1.

e. Accelerometer YF2.

f. Accelerometer ZF2.

9.1.3 General Electric Guidance Functions. Typical GE guidance measurements which yield accurate steering command inputs during the sustainer boost phase of flight and discrete functions for engine cutoff times are as follows:

a. VPT Pitch Output.

b. VPT Yaw Output.

c. Discrete Binary 1.

d. Discrete Binary 2.

e. Discrete Binary 4.

f. Discrete Binary 8

9.1.4 Atlas Autopilot Functions. The measurements used by Convair to evaluate the autopilot performance may also be of value to the payload contractor. The rate gyros

provide a direct indication of roll, pitch and yaw rates throughout flight including the period of payload separation. Comparable data from flight-to-flight is available. The Atlas autopilot functions measured are as follows:

a. Roll Displacement Gyro Signal.

b. Pitch Displacement Gyro Signal.

c. Yaw Displacement Gyro Signal.

d. Roll Rate Gyro Signal.

e. Pitch Rate Gyro Signal.

f. Yaw Rate Gyro Signal.

9.1.5 Vehicle Attitude. The Atlas booster attitude at the time of separation can be provided through either of the following two methods:

a. For boosters equipped with Arma guidance, the ASCAT includes provisions for monitoring the guidance platform position in analog form. A direct measurement of Atlas attitude in pitch and roll is available; or,

b. Atlas rate gyro data can be integrated with a tracking reference or Arma guidance data. The accuracy is within ±1 degree.

9.1.6 Vehicle Tracking. Vehicle position, velocity and acceleration data can also be obtained from the following tracking data sources.

a. Range tracking radar.

b. GERTS data.

c. GERTS guidance data.

Vehicle tracking data is available in the 72-hour data package supplied by the test range. Arma data is not supplied routinely, but may be obtained through BSYT approximately 60 days after launch.

9.1.7 Discrete Functions. All discrete functions are monitored to record the times at which command signals are sent to the payload. Typical discrete commands are as follows:

a. Booster Engine Cutoff.

b. Sustainer Engine Cutoff.

c. Vernier Engine Cutoff.

d. Payload Separation Signal.

9.1.8 Axial Acceleration. This measurement provides an accurate acceleration profile along the longitudinal axis of the booster and is responsive to axial disturbances of the boost vehicle. It is useful in determining the exact time of engine cutoff, evaluation of thrust decay characteristics. shroud separation, retrorocket firing time. and payload separation. These event times can be determined within plus or minus one millisecond.

9.1.9 Payload Separation Indication. This measurement monitors the physical separation of the payload from the booster at the payload/separation system interface.

9.2 SIDE MOUNTED PAYLOADS. An instrumentation interface exists in booster Quads 1 and 3 capable of monitoring seven measurements in each quad. (See Figure 3-2.)

9.3 AVAILABLE INSTRUMENTATION SPACE. Booster-system measurements utilize most of the capacity of the AIRSS telemeter. However, some space and growth capability are available for the addition of mission peculiar instrumentation. The payload contractor may be allowed to share this space with other associate contractors who may have mission peculiar requirements. Present measurement configuration requires all continuous channels to be utilized. Certain continuous channel measurements can be re-aligned, if a need is established.

Space is presently available for 9 measurements on commutated channel 14 at 5 samples per second and 19 measurements on commutated channel 15 at 10 samples per second.

9.4 ADDITIONAL INSTRUMENTATION CAPABILITY. If the extra instrumentation capability available on Atlas E/F boosters is insufficient to meet payload mission requirements, space and power is available on the booster for installation of two additional telemeters. The requirement for additional telemeters has to be approved by BSD, and interface requirements are mutually agreed upon between the payload contractor and Convair. Section 12 describes in detail the payload integration requirements for instrumentation.

9.5 LANDLINES. A wide range of instrumentation capability at ABRES A, including signal conditioning, high and low frequency strip chart recording, and FM tape systems is available for payload measurements. Provision for transmitting the measurement analog signals for display on payload console meters is also available. A block diagram of the ABRES landline measurement system is included as Figure 9-1.

9.5.1 Landlines Interface. The landlines system interfaces with the payload and payload equipment at the payload cable distribution units (CDUs) in the LSB and in the LOB. Measurement channels are picked up at the CDUs through "patch" connections at the payload CDU patch panels. Connections to the console meters is via the LOB payload CDU.

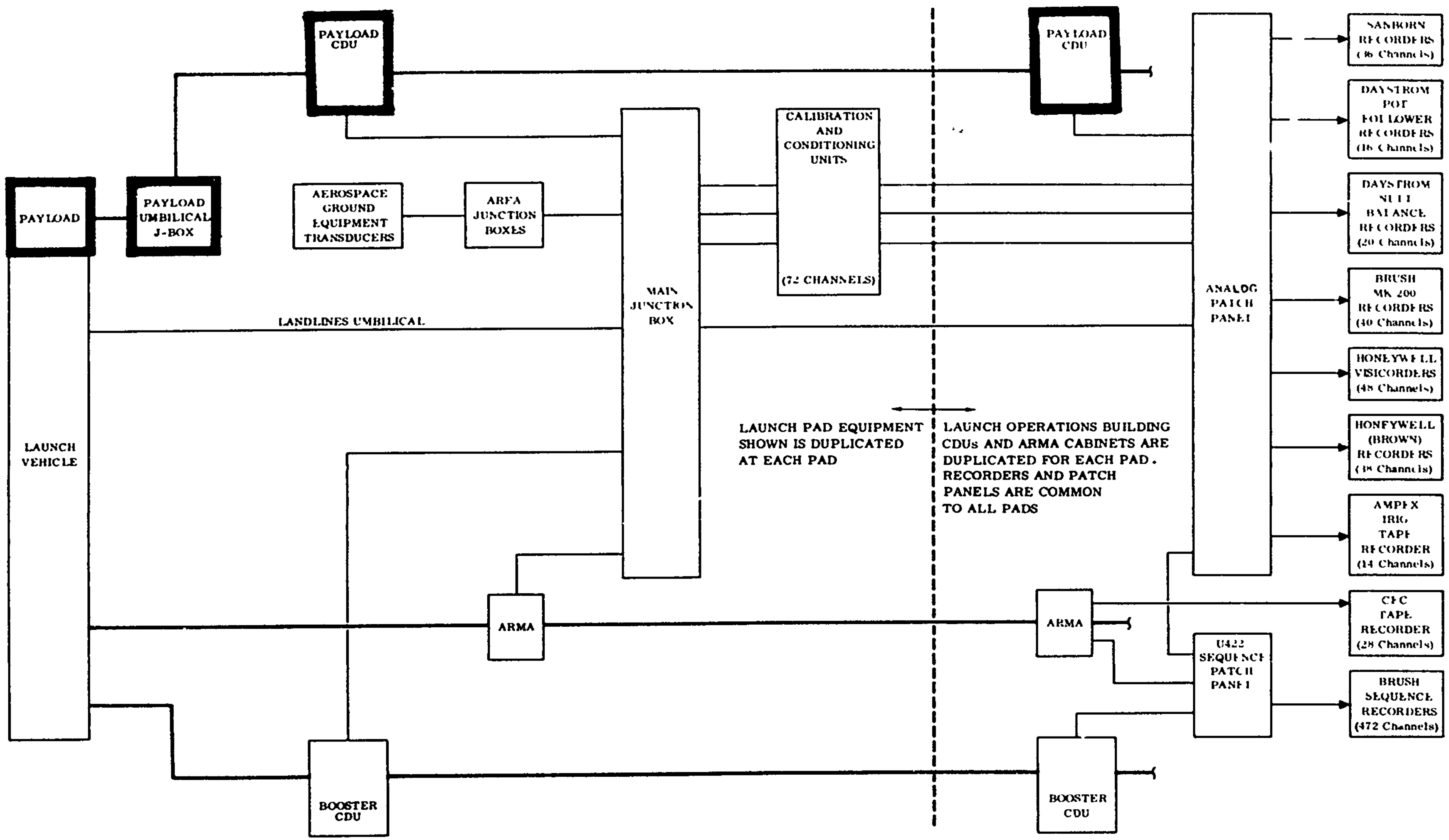


Figure 9-1. Landlines Measurement System at ABRES A

9.5.2 Landline Conditioning and Calibration. Seventy-two conditioning and calibration channels are provided in three conditioning units at each pad. Approximately 50 channels are used for baseline booster measurements. Included are provisions for AC and DC excitation and amplification. The signal returning from transducers or voltage pickup is adjusted to the voltage, current, or frequency level required for the landline recorders. Automatic calibration of the measurement channel is provided by circuits controlled either at the conditioning units or at the instrumentation control console in the LOB.

9.5.3 Landlines Recorders. Direct writing recorders and magnetic tape recorders are available at ABRES A. Figure 9-1 lists the recorders and the total number of channels available for payload and booster use. Recording capability reserved for payload users requirements include 20 channels of medium frequency strip charts, 20 FM tape channels, and 40 sequence measurement channels. Associated with the recording capability reserved for the payload user is an 8 channel meter adjust panel, which may be used to adjust a measurement signal to a range suitable for visual display on a console meter. See Table 9-1.

9.6 CLOSED LOOP TELEVISION SYSTEM. The ABRES A television system provides means for remote observation of the booster and payload during checkout and countdown operations. It is designed for closed circuit operation and contains a built-in communication network used during setup and checkout operations. A total of 10 chains (each chain consists of a camera, monitor, cabling, and controls) are available at ABRES A. Three cameras are installed at each pad, one at the LSB, and one at the LOB TV tower. See Figure 9-2.

Table 9-1. Number of Recorder Channels Required vs. Number of Available Channels. Typical

SYSTEM	ANALOG RECORDERS							SEQUENCE RECORDERS
	DIRECT READOUT STRIP CHART				QUICK LOOK STRIP CHARTS	POST-TEST DATA		
	GRAPHIC 1 Hz	LOW FREQ STRIP CHART 50 Hz			OSCILLO-GRAPH 2 KHz 24 chan	AM/FM MAG. TAPE	IRIG FM TAPE 2 KHz	120 chan
	single, dual chan	8 chan DC	8 chan AC	6 chan AC & DC				
Booster							6	
Electrical	2				4			8
Pneumatic	14							43
Air Conditioning	2							
Hydraulic	4				2			13
Propulsion	13				2			33
Missile Reference Junction	1							
Autopilot		2	24					26
Propellant Loading	2	7						84
G. E. Guidance		8			16			
Reference Sequence Data					8			
Launch Control & Facilities								40
Booster Total	38	17	24 Special for Autopilot	0 Special for ARMA	32	0 Special for ARMA	6	247
Available Channels to Payload		20					20	40

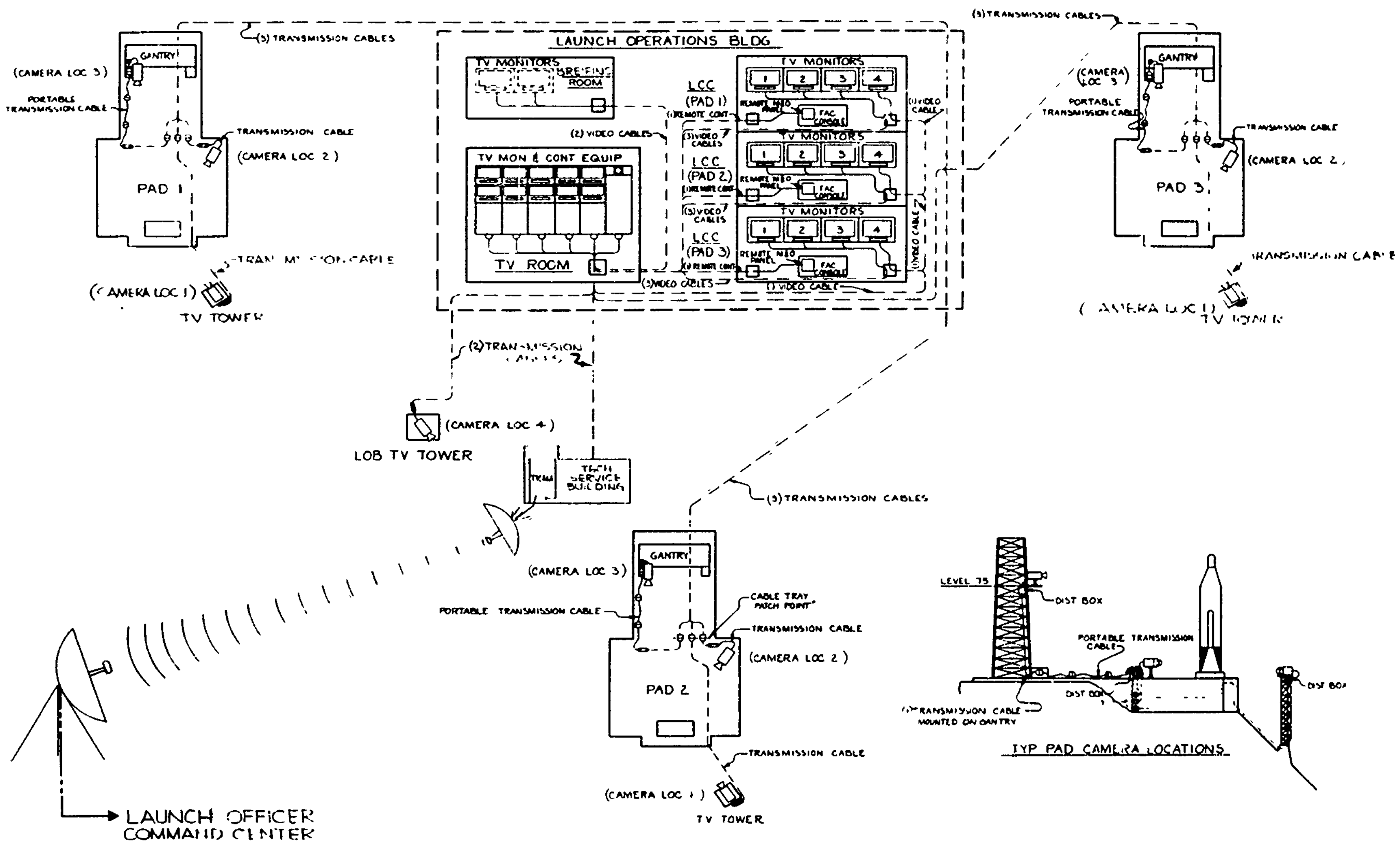


Figure 9-2. ABRES A Closed-Loop Television System

SECTION 10
ABRES A LAUNCH COMPLEX

The ABRES-A launch complex at AFWTR Vandenberg, Calif. consists of three separate launch pads, associated launch service buildings, and a single launch operations (control center) building. Figure 10-1 depicts the ABRES-A complex.

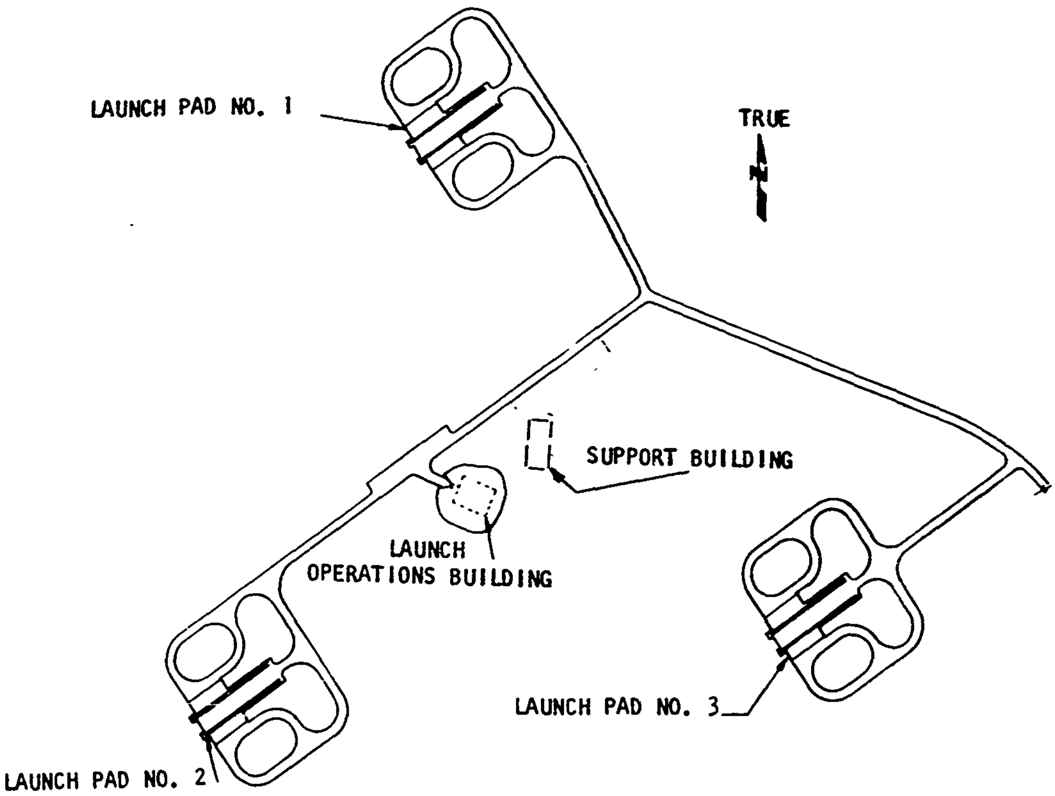
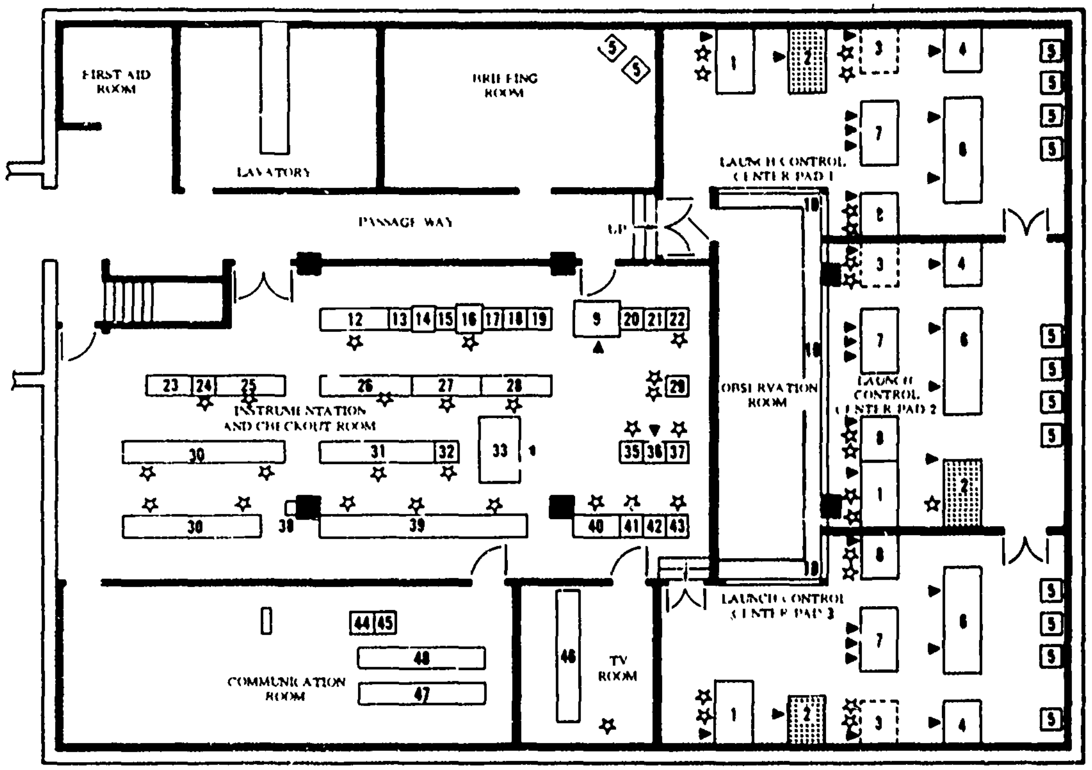


Figure 10-1. ABRES A Complex

Each launch pad contains aerospace ground equipment (AGE) and facilities for servicing, checkout, and launch of an Atlas E/F booster. The launch operations building (LOB) contains separate launch control centers for each pad and an instrumentation room. Figures 10-2 and 10-3 depict the general arrangement of the launch operations building.

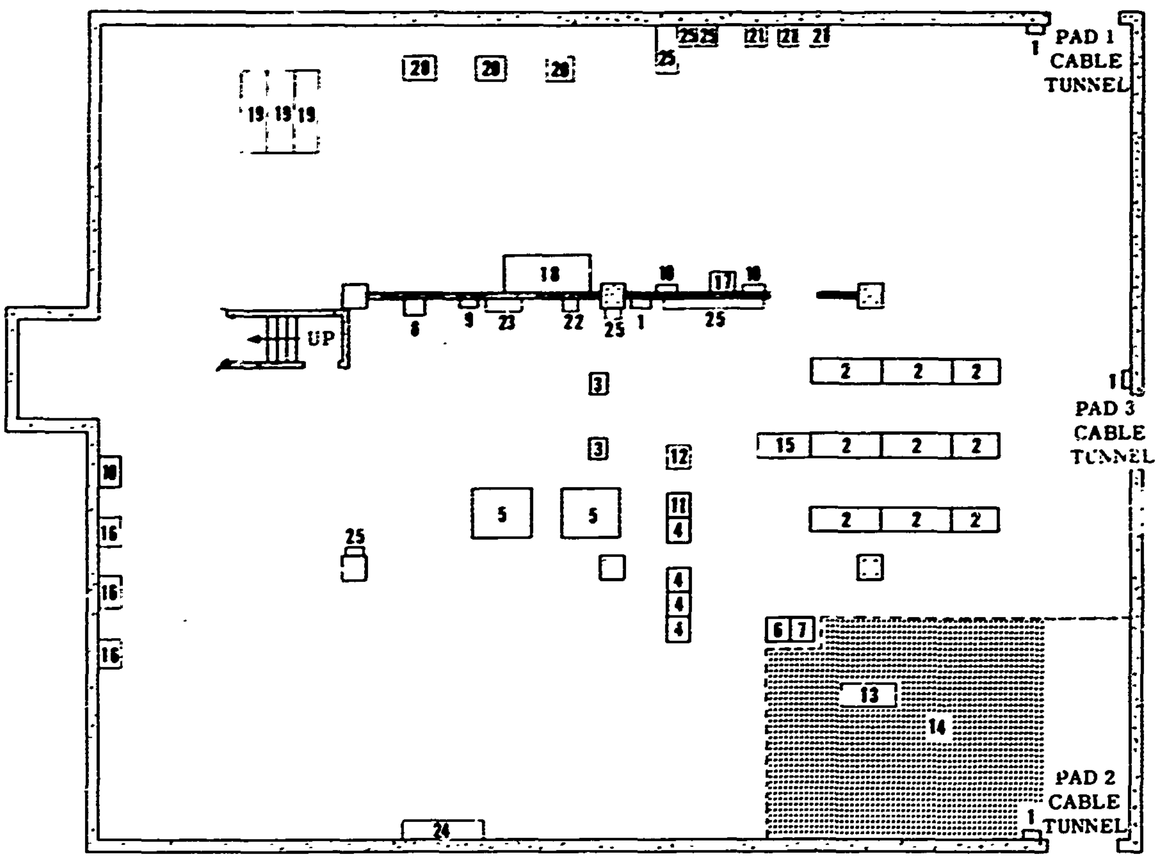
Certain provisions have been built into ABRES-A sites for the exclusive purpose of servicing payloads during checkout, maintenance, and launch. These include space reserved for associate contractor's monitoring and checkout equipment, the universal umbilical tower (UUT), payload cabling, and payload coolant and air-conditioning systems. Other provisions exist within the AGE and facilities that can be shared with payload contractors. These include the booster service tower, primary ground power, and auto collimation for guidance systems.



1. OPERATION AND CONTROL CONSOLE
2. PAYLOAD CONSOLE
3. SAFETY CONSOLE
4. FACILITIES CONSOLE
5. TELEVISION MONITOR
6. COUNTDOWN AND MONITORING CONSOLE (LOP/LAP)
7. TEST CONTROLLER CONSOLE
8. TALKER CONSOLE
9. MOVIE CAMERA CONTROL
10. CHIEF TABLE
12. CEC TAPE RECORDER
13. GUIDANCE OSPA PAD 2
14. SANBORN RECORDER PAD 2
15. GUIDANCE OSPA PAD 1
16. SANBORN RECORDER PAD 1
17. SPACE
18. PROPELLANT UTILIZATION CABINET
19. PROPELLANT UTILIZATION CABINET
20. AUTOPILOT MONITOR UNIT - PAD 1
21. AUTOPILOT TRANSFER FUNCTION ANALYZER - PAD 1
22. AUTOPILOT CONSOLE - PAD 1
23. OV 1 EQUIPMENT
24. SANBORN RECORDERS
25. IRIG TAPE RECORDERS
26. BRUSH SEQUENCE RECORDERS
27. SEQUENCE PROGRAM PANEL
28. ANALOG PATCH PANEL
29. GERSIS/GUIDANCE REMOTE MONITOR
30. BROWN RECORDERS
31. BRUSH RECORDERS
32. TIMING RELAY BOX
33. INSTRUMENTATION CONSOLE
35. AUTOPILOT MONITOR UNIT - PAD 3
36. AUTOPILOT TRANSFER FUNCTION ANALYZER - PAD 3
37. AUTOPILOT CONSOLE - PAD 3
38. POWER DISTRIBUTION BOX
39. DAYSTROM RECORDERS
40. SANBORN RECORDERS
41. AUTOPILOT MONITOR UNIT - PAD 2
42. AUTOPILOT TRANSFER FUNCTION ANALYZER - PAD 2
43. AUTOPILOT CONSOLE - PAD 2
44. TLM CHECKOUT UNIT NO. 1
45. TLM CHECKOUT UNIT NO. 2
46. TELEVISION EQUIPMENT

▶ COMMUNICATION PANEL
☆ JACK STATION
COUNTDOWN & P. A. SPEAKERS IN EACH ROOM

Figure 10-2. Launch Operations Building (LOB) Floor Plan



1. TERMINAL CABINET, IT
2. CABLE DISTRIBUTION UNIT
3. POWER SUPPLY
4. POWER DISTRIBUTION SET
5. BATTERY, 28 V
6. ANTIFIRE SYSTEMS CABINET
7. IRSS CABINET
8. REMOTE CONTROL & INDICATOR CABINET
9. DC POWER DISTRIBUTION CABINET, 120 V
10. LIGHTING PANELS
11. PEM CONTROL AND MONITOR - PADS 1 AND 3
12. PU MONITORS SWITCHING CABINET
13. PAYLOAD CABLE DISTRIBUTION UNIT
14. SPACE FOR PAYLOAD AGE
15. USAF COUNTDOWN CLOCK
16. TRANSFORMER, 15 KVA, 480/120-208 V
17. STABILIZING TRANSFORMER, 3 KVA, 118 VAC REG.
18. BATTERY, 120 V
19. SWITCHGEAR, 4160 V
20. TRANSFORMER, 167 KVA, 4160/480 V
21. TRANSFORMER, 50 KVA, 480/120-208 V
22. TRANSFORMER, 5 KVA, 480/120 V
23. 120 V RECTIFIER/CHARGER
24. LOB MOTOR CONTROL CENTER
25. DISTRIBUTION PANEL

Figure 10-3. Launch Operations Building (LOB) Basement Floor Plan

10.1 PAYLOAD AGE SPACE PROVISIONS. Figure 10-2 shows the location of the payload console for each of the launch pads. The payload console, Figure 10-4, is a multiple-bay console enclosure into which payload contractor control and monitor panels or control chassis required for launch can be mounted. Total panel space is available except that used for communication panels installed in the two outermost bays. Near the base of the console is a connector panel on which cables are mounted that run to the LOB cable distribution units (CDU). The point of electrical interface with the payload contractor's launch monitor and control equipment is at this connector panel.

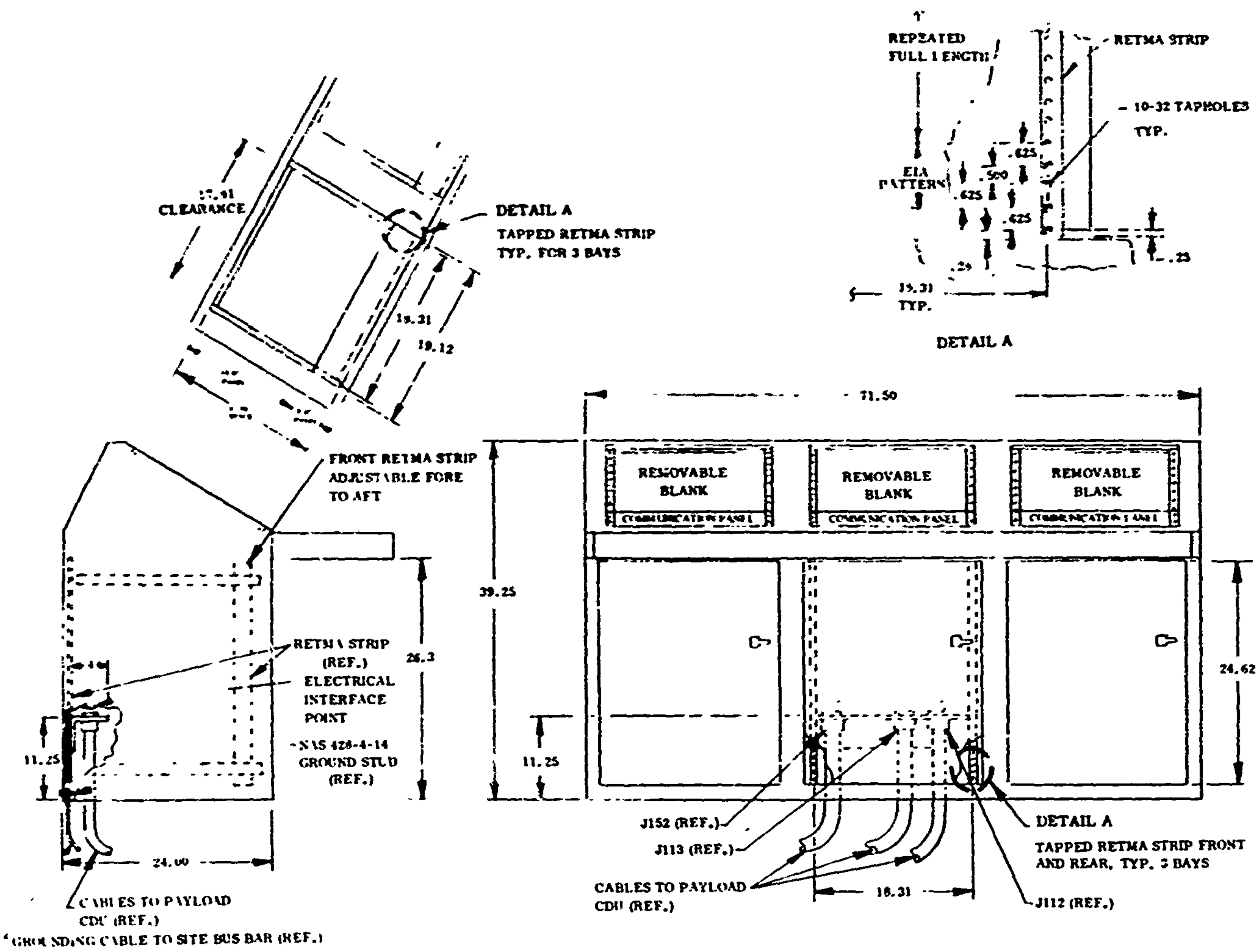


Figure 10-4. Payload Console

Figure 10-3 shows the 18 × 24 foot area of the LOB basement where payload AGE can be installed. The payload CDU's are located within this area which is physically below the Pad 3 launch control center. Figure 10-5 is an expanded view of this area. The shaded areas represent mounting bases provided for installation of payload AGE.

The LSB mechanical and electrical (M&E) room, Figure 10-6, is typical of the three pads and shows an approximate 10-1/2 × 18-foot area reserved for payload AGE. The LSB CDU is located within this area. Figure 10-7 is an enlarged view of the area with a shaded portion showing the existing mounting base.

Figure 10-8 shows a typical payload AGE installation for either LOB or LSB. Existing cables with connectors drop from overhead cable trays to interface with payload AGE.

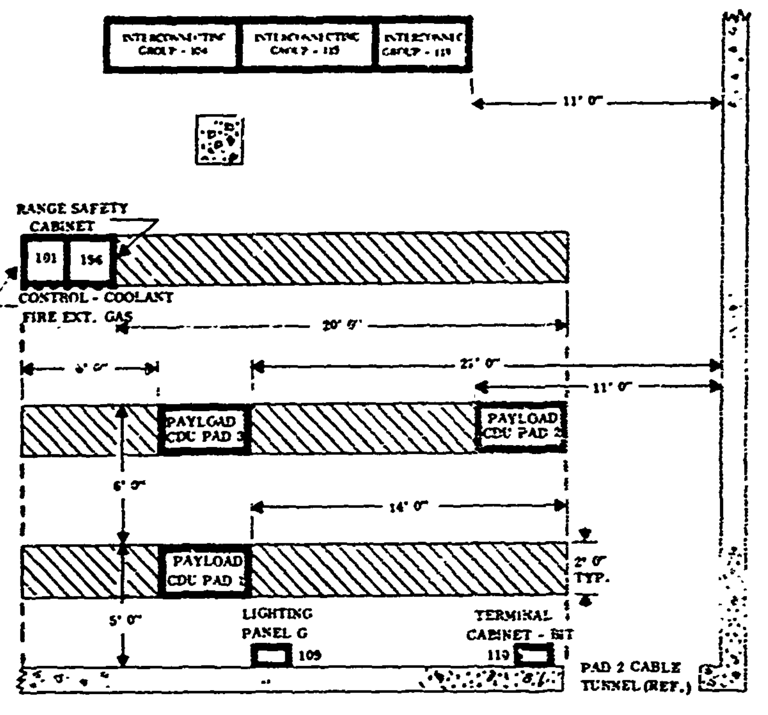
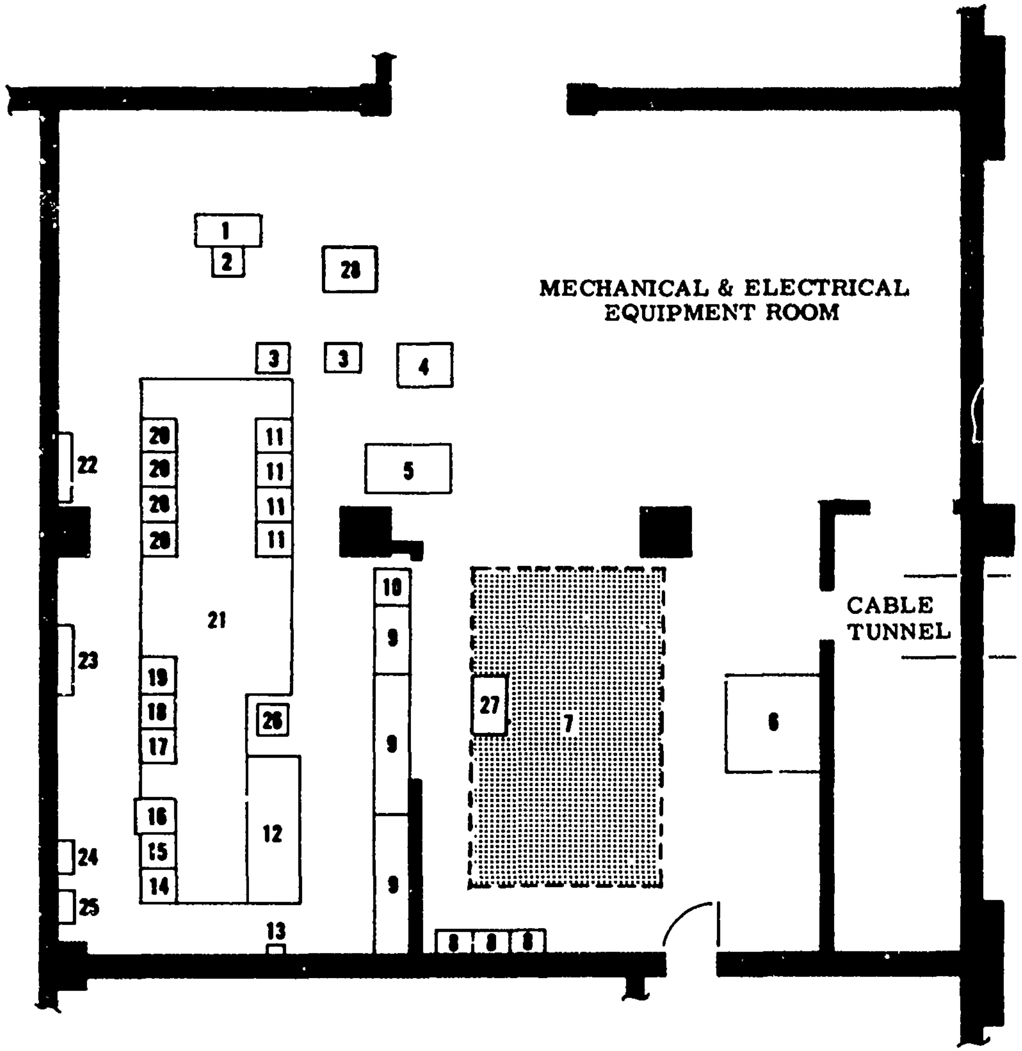


Figure 10-5. Space Provisions for Payload Equipment in LOB Basement

10.2 UNIVERSAL UMBILICAL TOWER (UUT). A tower, approximately 130 feet high, is located in Quadrant 1 (of each launch pad) for servicing the payload with umbilicals for electrical, fluid, and air conditioning requirements. The tower is located outside the drift envelope of the booster and is provided with a retractable boom from which umbilicals are attached to the payload. In the extended position, the boom is capable of being positioned from 6 to 15 feet from the centerline of the booster at positions of 6,8,9,10, 12, or 15 feet. All tower platforms are accessible by stairs. In addition, when in the extended position, Stations 70 to 100 of the boom may be reached from the booster service tower. Figure 10-9 depicts the general arrangement of the UUT. The UUT boom is retracted automatically during the final phase of countdown by a pneumatic/hydraulic piston mechanism upon command from booster launch control logic.

Located on the boom is an umbilical retraction system for ejecting and retracting payload umbilicals upon command, prior to liftoff. The umbilical retraction system consists of four adjustable, pre-charged pneumatic cylinder/piston devices which, though a pulley arrangement, retract steel cables attached to umbilical connectors. The system can be adjusted to provide a maximum of 2100 pounds pull force; speed of operation varies directly with pressure. The pull points are located at the edges of the 36 inch wide boom and can be adjusted vertically from Station 70 to 100. The umbilical retraction system is designed so that, during normal operation, umbilicals will be demated prior to movement of the tower boom. Figure 10-10 presents the pneumatics schematic and Figure 10-11 the lanyard arrangement of the umbilical retraction system. Commands for ejection of electrically ejected umbilicals are provided just prior to engine start.



1. BATTERY
2. BATTERY CHARGER POWER SUPPLY
3. 28 VDC POWER SUPPLY
4. 115 V, 400 CPS, AC POWER SUPPLY, TYPE MD-2
5. GE PULSE SHAPER, RMV - PADS 1 AND 3 ONLY
6. AIR CONDITIONER
7. SPACE FOR PAYLOAD AGE
8. GE FACILITY TERMINAL CABINET
9. CABLE DISTRIBUTION UNIT
10. IRSS CABINET
11. POWER DISTRIBUTION UNIT
12. MONITOR AND CONTROL UNIT
13. MISSILE ORDNANCE TEST FIXTURE
14. AIG CDG 1A1
15. AIG CDG 1A2
16. AIG OSPA - PADS 1 AND 2 ONLY
17. AUTOPILOT MONITOR AND CONTROL UNIT
18. GE GUIDANCE ABETS AT PADS 1 AND 3, A/P POWER SUPPLY AT PAD 2.
19. GERSIS AND ABETS EQUIPMENT
20. LANDLINE INSTRUMENTATION EQUIPMENT
21. LAUNCH CONTROL AGE PLATFORM
22. LANDLINE INSTRUMENTATION TERMINAL CABINET
23. PROPELLANT TRANSFER TERMINAL CABINET
24. FACILITY POWER PANEL
25. RELAY BOX, AC POWER DISTRIBUTION
26. GE R/V PRE-LAUNCH MONITOR & SIMULATOR - PADS 1 AND 3 ONLY
27. PAYLOAD CABLE DISTRIBUTION UNIT
28. BATTERY - PADS 1 AND 3 ONLY.

Figure 10-6. M&E Room in Launch Service Building

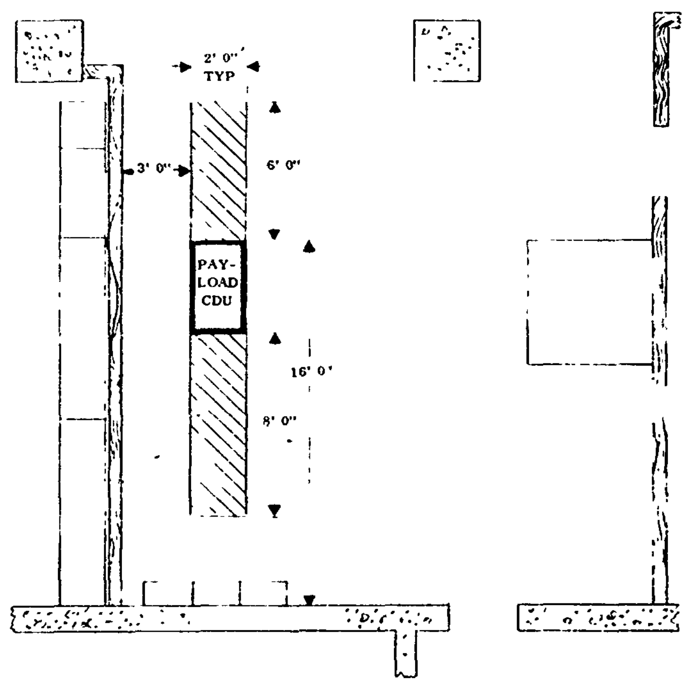


Figure 10-7. Space Provisions for Payload Equipment, LSB

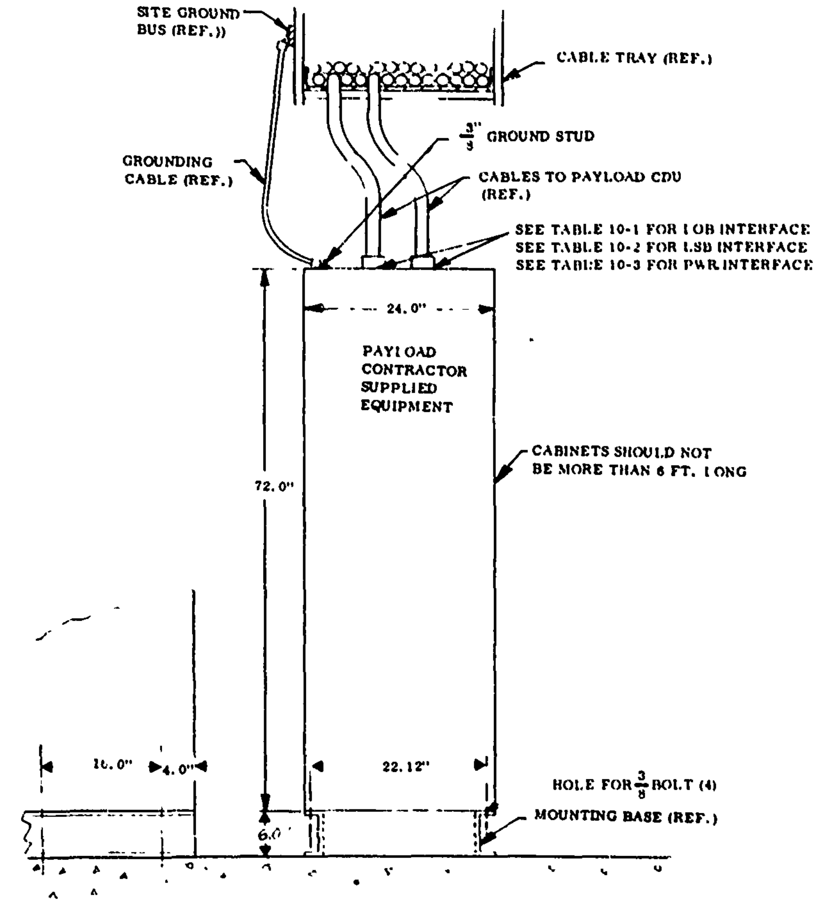


Figure 10-8. Typical Payload Contractor AGE Installation

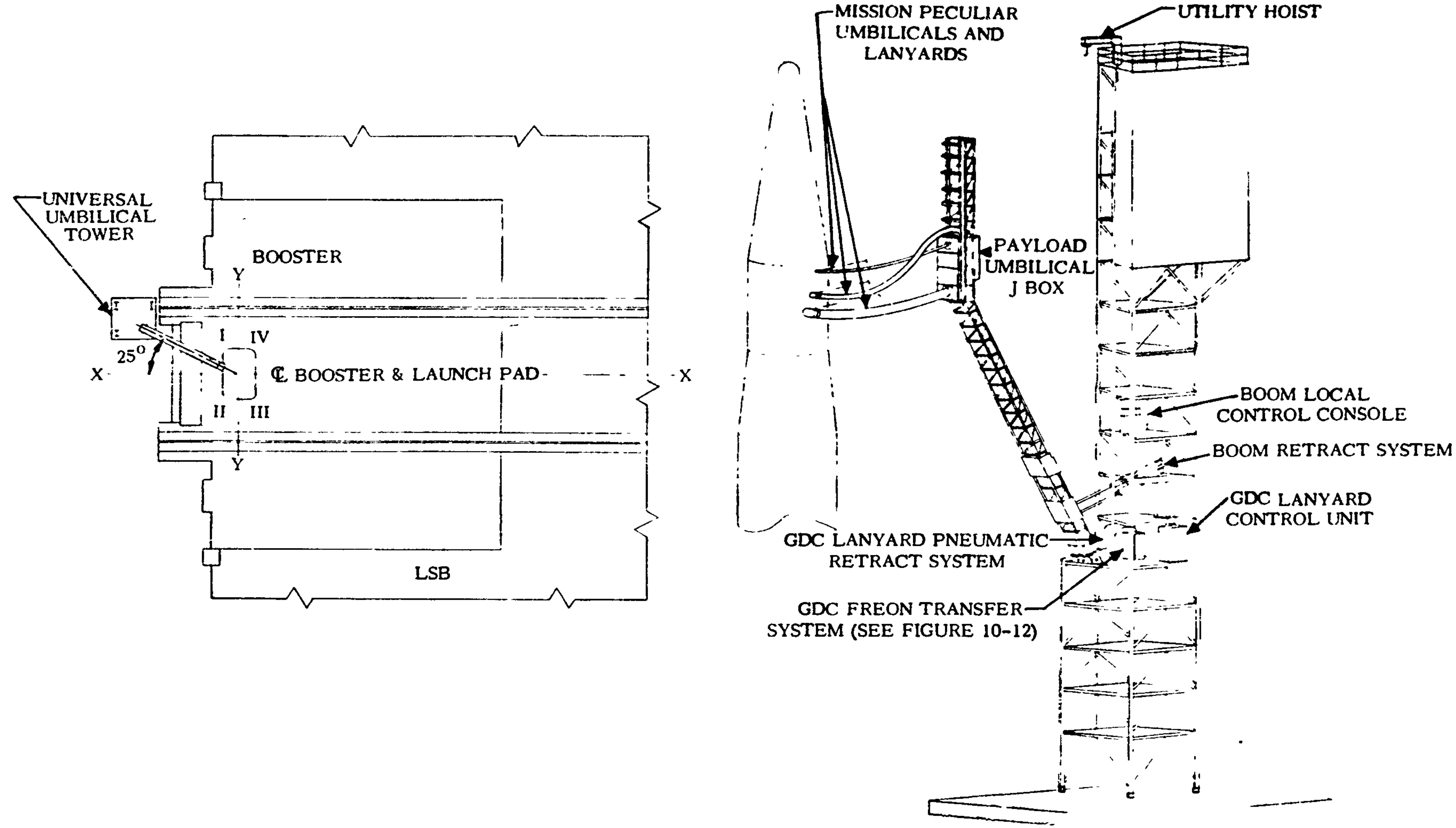


Figure 10-9. Universal Umbilical Tower

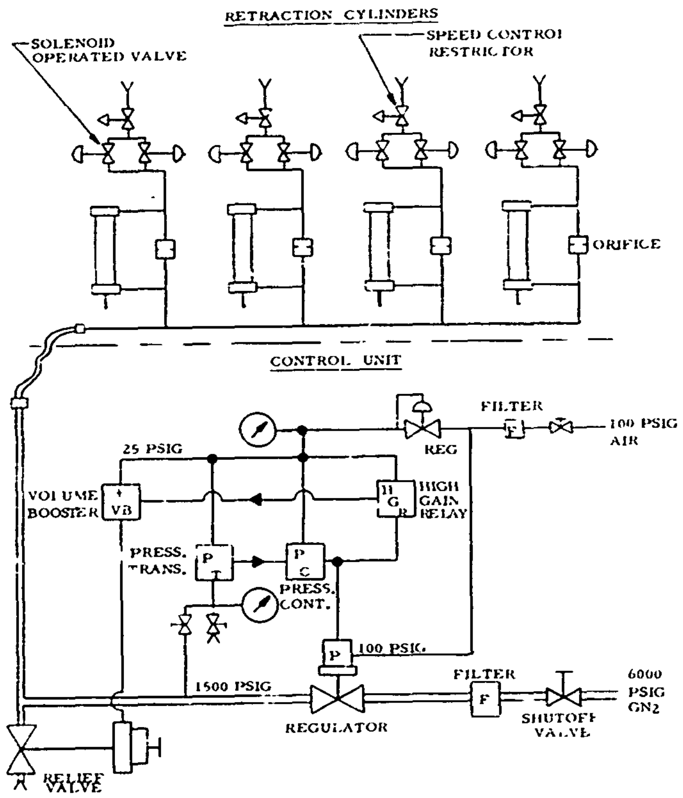


Figure 10-10. Umbilical Retraction System Pneumatic Schematic

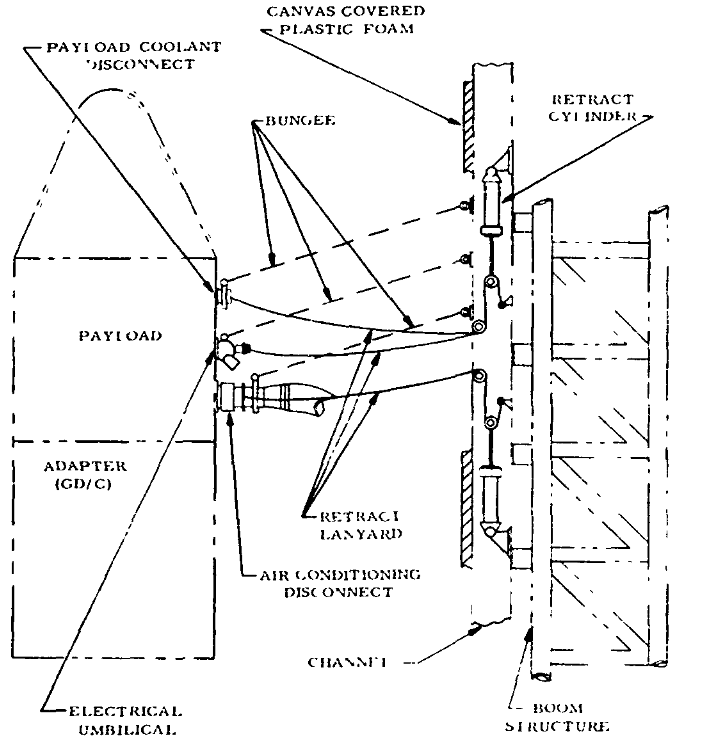


Figure 10-11. Umbilical Retraction System Typical Lanyard Attach Points

10.3 PAYLOAD CABLING CAPABILITY. A payload cabling capability, independent of booster and facility cabling, exists specifically to satisfy payload contractor requirements. This system has provisions for interconnecting payload-supporting AGE in the LOB and LSB with the payload. (See Figure 10-12.) Provisions also exist for an interchange of signals between the payload contractor, the booster launch system, and instrumentation. Facility power is provided through this system. It is intended that the large variety of cable construction provided will satisfy all payload contractor requirements. As shown in Figure 10-13, major items comprising the payload cabling system are the payload cable distribution units (CDU), payload umbilical junction box, and the interconnecting cables.

10.3.1 Cable Distribution Units. A payload cable distribution unit exists in the LOB basement and also in the LSB mechanical and electrical equipment room. These units are 2 × 4 × 6-foot racks containing terminal boards to accept No. 16 to 2/0 AWG conductors. The cables to support the payload terminate in these racks. Capability to interconnect the various cables entering the CDUs is provided through a programmable system that is an integral part of these units (see Figure 10-14). Patchboards for conductors up to No. 10 AWG are programmed by Convair division using patchcords to furnish the appropriate copperpaths required by the payload contractor. Bus bars and/or cross connects are used for No. 8 AWG and larger.

10.3.2 Payload Umbilical Junction Box. The payload umbilical junction box is a 2 × 3 × 8-foot unit with a hinged door and provisions for umbilical cable entry through the top. It is located on the UUT boom at approximately the Station 75 level. Access to the junction box is gained from the booster service tower when the UUT boom is extended. With the boom retracted, access is from the UUT. Limited space is available in this box for mounting payload contractor components that must of necessity be physically located close to the payload. See Figure 10-15 for space available. The bulk of the space in the junction box is taken by terminal boards required to make the transition from the tower cables to the payload umbilical cables.

10.3.3 Interconnecting Cables. Interconnecting cables with a variety of constructions exist as shown in Figures 10-16, 10-17, 10-18, and Tables 10-1 through 10-5. The various cables provide 66 conductors from the payload console to the payload CDU, 339 conductors from the LOB CDU to the LOB payload AGE, 451 long-run conductors from the LOB CDU to LSB CDU, 166 conductors from LSB CDU to Payload AGE in the LSB, and 577 conductors from the LSB CDU to the payload umbilical junction box on the UUT. In addition, 4 triaxial runs exist between the payload umbilical junction box, payload CDU's, and the ITT Kellogg multiplexer for closed-loop telemetry checkout. Should peculiar requirements dictate, additional copperpaths can be added to this system. Table 10-6 is a list of connector types currently used on umbilical cables. Table 10-7 gives the typical payload cabling resistance.

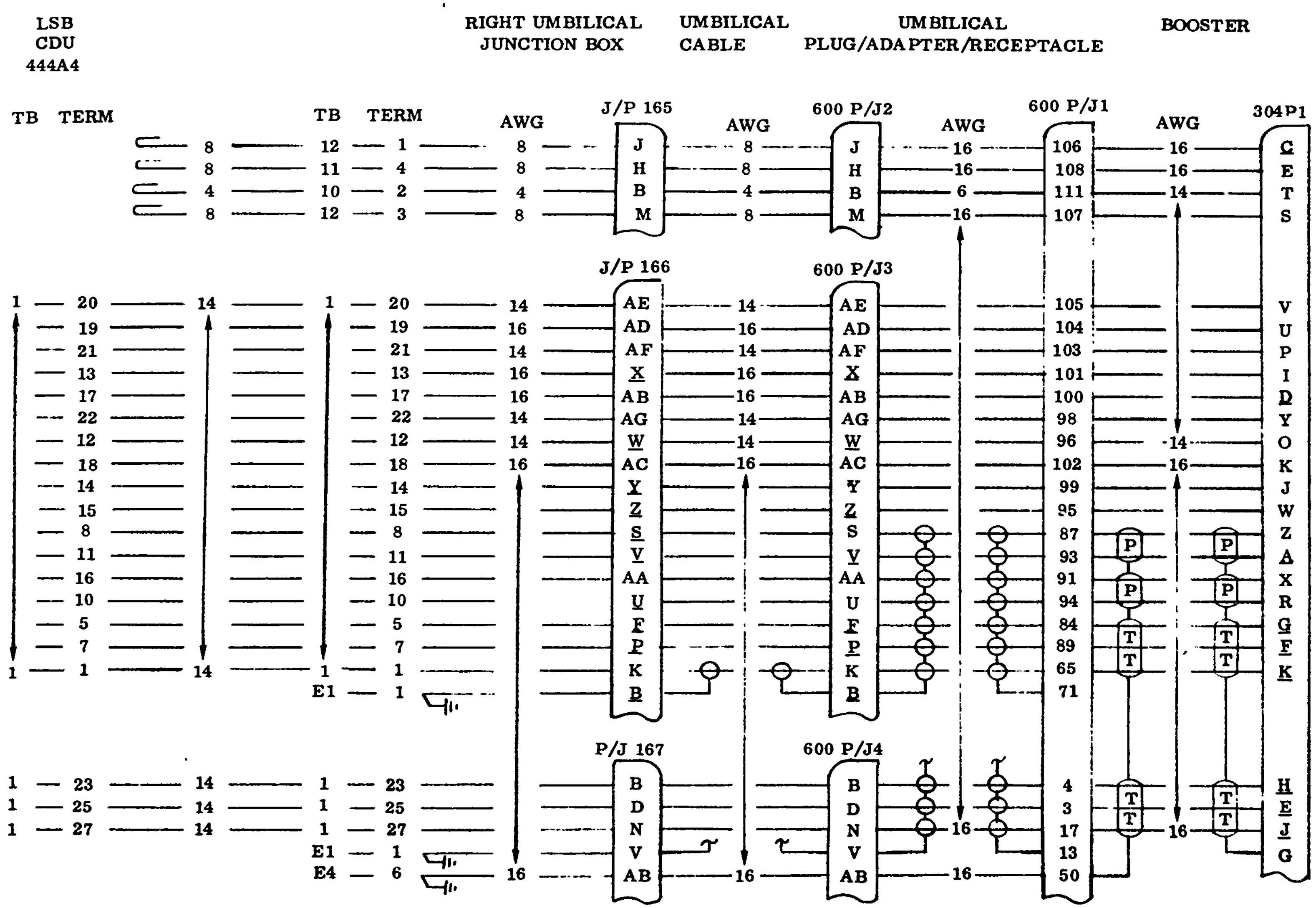


Figure 10-12. Payload Support Cabling via Booster.

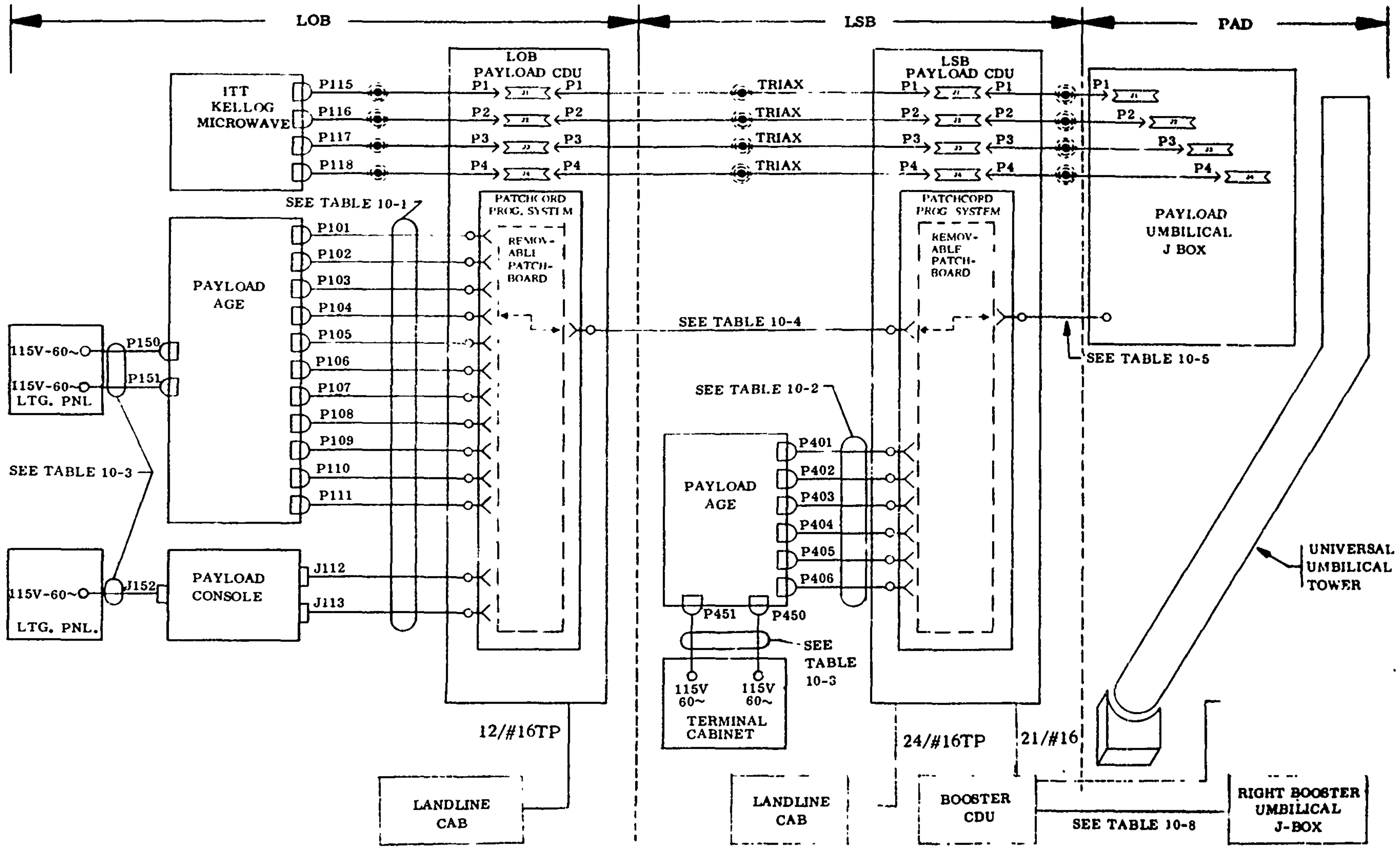


Figure 10-13. Payload Cabling Capability, Typical 3 Pads

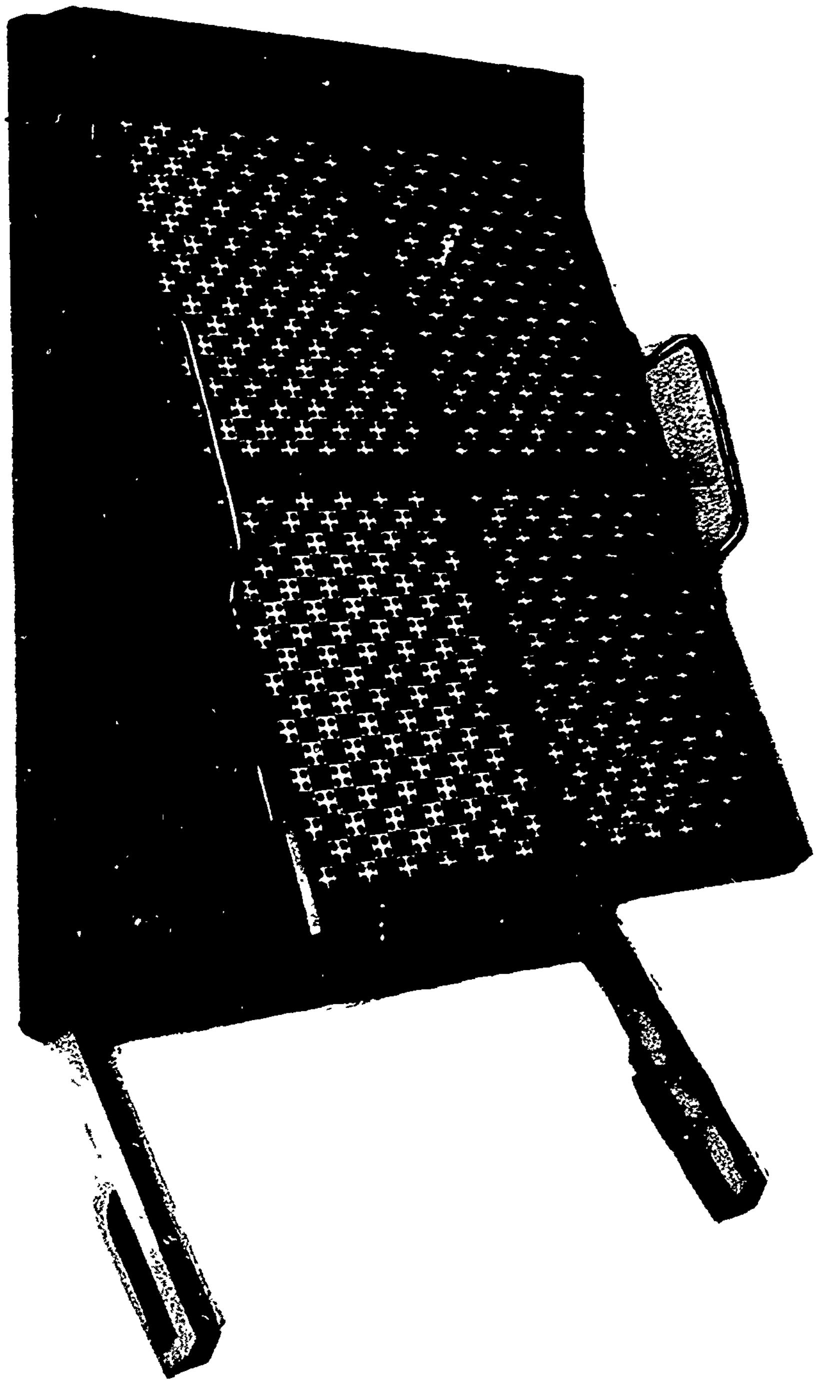


Figure 10-14. Programmable Patchboard

10.3.4 RF Shielding. RF shielding (raceways) is provided for all conductors between the payload umbilical J-Box and the LSB. Also, RF shielding is provided for certain cables, as shown in Table 10-4, between the LSB and LOB.

The RF shielding provides a minimum of 40 db attenuation between 200 KHz and 10 MHz and 20 db attenuation between 10 MHz and 10 GHz.

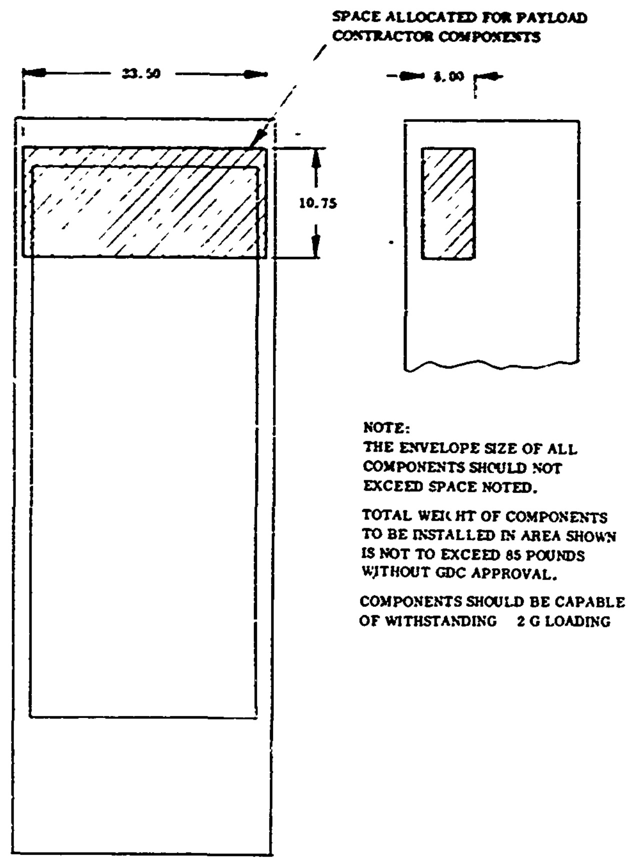


Figure 10-15. Payload Umbilical J-Box Maximum Component Envelope Size

Table 10-1. LOB P/L AGE Interface Cabling

CONN. REF. DES.	CONNECTOR PART NUMBER		FIG. NO.	CONVAIR CABLE ASSY NO.
	BENDIX QWL	CONVAIR PCN NO.		
P101	83-107636-7S	81-55206-851	10-16	27-30307-2
P102	83-107636-9S	81-55206-871	10-17	27-30308-2
P103	83-107636-7H	81-55206-853	10-16	27-30307-4
P104	83-107636-7J	81-55206-855	10-16	27-30307-5
P105	83-107636-9H	81-55206-873	10-17	27-30308-4
P106	83-107636-7L	81-55206-857	10-16	27-30307-6
P107	83-107636-7S	81-55206-851	10-16	27-30307-2
P108	83-107636-9S	81-55206-871	10-17	27-30308-2
P109	83-107636-7H	81-55306-853	10-16	27-30307-4
P110	83-107636-7J	81-55306-855	10-16	27-30307-5
P111	83-107636-7L	81-55206-857	10-16	27-30307-6
J112	83-107336-7S	81-55203-850	10-16	27-30307-7
J113	83-107336-7H	81-55203-852	10-16	27-30307-8

NOTE: Above connector part numbers are used on Convair cables. Payload contractor should use mating connectors on payload AGE.

Table 10-2. LSB P/L AGE Interface Cabling

CONN. REF. DES.	CONNECTOR PART NUMBER		FIG. NO.	CONVAIR CABLE ASSY NO.
	BENDIX QWL	CONVAIR PCN NO.		
P401	83-107636-9S	81-55206-871	10-17	27-30308-1
P402	83-107636-9H	81-55206-873	10-17	27-30308-3
P403	83-107636-7S	81-55206-851	10-16	27-30307-1
P404	83-107636-9J	81-55206-875	10-17	27-30308-5
P405	83-107636-9L	81-55206-877	10-17	27-30308-6
P406	83-107636-7H	81-55206-853	10-16	27-30307-3

NOTE: Above connector part numbers are used on Convair cables. Payload contractor should use mating connectors on payload AGE.

Table 10-3. Power Cables

CONN. REF. DES.	CONNECTOR PART NUMBER		FIG. NO.	CONVAIR CABLE ASSY NO.
	BENDIX QWL	CONVAIR PCN NO.		
J152	83-107328-3S	81-55203-598	10-18	27-30305-2
P150	83-107628-3S	81-55206-599	10-18	27-30305-1
P151	83-107628-3S	81-55206-599	10-18	27-30305-1
P450	83-107628-3S	81-55206-599	10-18	27-30305-1
P451	83-107628-3S	81-55206-599	10-18	27-30305-1

NOTE: Above connector part numbers are used on Convair cables. Payload contractor should use mating connectors on payload AGE.

Table 10-4. LOB to LSB - Conductor Capability

CONFIGURATION	TOTAL CONDUCTORS
152/#16 Single Conductor	152
23/#16SSJ	24
6/#16TPSJ	12
24/#16TPSJ - 25 PF/FT	48
14/#16TPSJ - 40 PF/FT - RF Shield	28
1/#16TTSJ - 50 PF/FT - OAS	3
1/#16T5SJ - 50 PF/FT - OAS	5
12/#16T4SJ	48
1/#16TTSJ - 40 PF/FT - RF Shield	3
2/#16T5SJ - 40 PF/FT - RF Shield	10
2/#16T8SJ - 40 PF/FT - RF Shield	16
2/#16SSJ - RF Shield	2
1/#16T5SJ - RF Shield	5
1/#16T9SJ - RF Shield	9
30/#14SSJ - 40 PF/FT - RF Shield	30
2/#14TTSJ - 40 PF/FT - RF Shield	6
8/#12SSJ	8
14/#8 Single Conductor	14
7/#6TPSJ	14
4/#4 Single Conductor	4
6/#1/0 Single Conductor	6
4/#RG-58 A/U - TRI-AX	4
	451

SJ	Shielded and jacketed	T5	Twisted quint
SSJ	Single conductor SJ	T8	Twisted eight
TP	Twisted pair	T9	Twisted nine
TT	Twisted triad	PF/FT.	Picofarad per foot
T4	Twisted quad	OAS	Overall shield

Table 10-5. LSB to UUT P/L UJB - Conductor Capability

CONFIGURATION	TOTAL CONDUCTORS
144/#16 Single Conductor	144
41/#16SSJ	41
22/#16SSJ - 40 PF/FT	22
6/#16TPSJ	12
38/#16TPSJ - 25 PF/FT	76
2/#16TTSJ	6
2/#16TTSJ - 50 PF/FT - OAS	6
3/#16T4SJ	12
2/#16T5SJ - 50 PF/FT - OAS	10
78/#14 Single Conductor	78
3/#14SSJ	3
20/#14TPSJ	40
2/#14T9SJ - 40 PF/FT	18
8/#12 Single Conductor	8
8/#12SSJ	8
10/#10TPSJ	20
16/#8 Single Conductor	16
1/#4SSJ	1
8/#4TPSJ	16
8/#4TP	16
12/#2 Single Conductor	12
12/#2/0 Single Conductor	12
4/RG-58 A/U TRI-AX	4
	581

SJ	Shielded and jacketed	T5	Twisted quint
SSJ	Single conductor SJ	T8	Twisted eight
TP	Twisted pair	T9	Twisted nine
TT	Twisted triad	PF/FT.	Picofarad per foot
T4	Twisted quad	OAS	Overall shield

Table 10-6. Umbilical Connectors

CONVAIR PART NO.	CONTACT SIZE	RELEASE MECHANISM PRIMARY	RELEASE MECHANISM SECONDARY	REMARKS
81-55331-005	14(#16), 27(#20)	Lanyard	None	
55-01643-5	55(#20)	Lanyard	None	Tri OV1
81-55961-001	206(#16), 8(#12), 2(#8), 1(#4)	Elect	Lanyard	
27-06172-821	108(#16), 4(#RG-71/U)	Elect	Lanyard	
27-06172-829	78(#16), 6(#12) 7(#RG-71/U)	Elect	Lanyard	
27-06172-831	107(#16), 4(#6)	Elect	Lanyard	E & F Booster Umbilicals
27-06172-823	66(#16), 4(#8), 6(#4)	Elect	Lanyard	
27-06172-833	109(#16), 15(#12)	Elect	Lanyard	
27-06172-835	84(#16), 8(#12), 3(#RG-63/U)	Elect	Lanyard	
GFP	188(#16), 8(#12)	Lanyard	Mech	Includes air-conditioning duct and two fluid lines
27-04998-69	109(#16), 15(#12)	Solenoid	Lanyard	MBRV and SLV booster
27-04998-63	107(#16), 4(#4)	Solenoid	Lanyard	SLV booster umbilical
27-04998-65	3(#RG-63/U), 84(#16), 8(#12)	Solenoid	Lanyard	SLV booster umbilical
27-04998-67	66(#16), 4(#8), 6(#4)	Solenoid	Lanyard	SLV booster umbilical
27-04998-71	4(#RG-71/U), 108(#16)	Solenoid	Lanyard	SLV booster umbilical
69-06100-1	91(#16)	—	—	Receptacle qualified for extreme high-temperature re-entry environment. Plugs qualified to booster environment.
69-06102-1	91(#16)	Mech	Mech	
69-06101-1	37(#16)	—	—	
69-06103-1	37(#16)	Lanyard	Mech	Ref. Spec. 69-06104.
55-06272	74(#20), 14(#16)	Mech or Elec	Mech or Elec	AC lift-off umbilical. Qualified for Centaur
55-06785	52(#16), 6(#12)	Mech or Elec	Mech or Elec	AC interstaging plug
81-55331-001	19(#20)	Lanyard	None	SLV instrumentation staging. SLV instrumentation has excellent background with these "Twistlock" types
81-55331-006	26(#20)	Lanyard	None	
81-55331-004	16(#16)	Lanyard	None	
81-55331-002	55(#20)	Lanyard	None	
27-01389-3	104(#16)	Elec	Lanyard	Dual OV-1; has also been used as an instr. Trailing umbilical disconnect.

Table 10-7. Typical Payload Cabling Resistance

DESTINATIONS	CONDUCTOR GAUGE									
	16	14	12	10	8	6	4	2	0	00
AGE to CDU	0.19	—	0.08	—	0.03	—	0.01	—	—	—
Console to LOB/CDU	0.55	—	0.23	—	—	—	—	—	—	—
LOB/CDU to LSB/CDU	6.80	4.30	2.70	—	1.06	0.67	0.42	—	0.17	—
LSB/CDU to UJB/UUT	1.62	1.03	0.64	0.45	0.25	—	0.10	0.06	—	0.03

— Indicates conductors not available in cables.

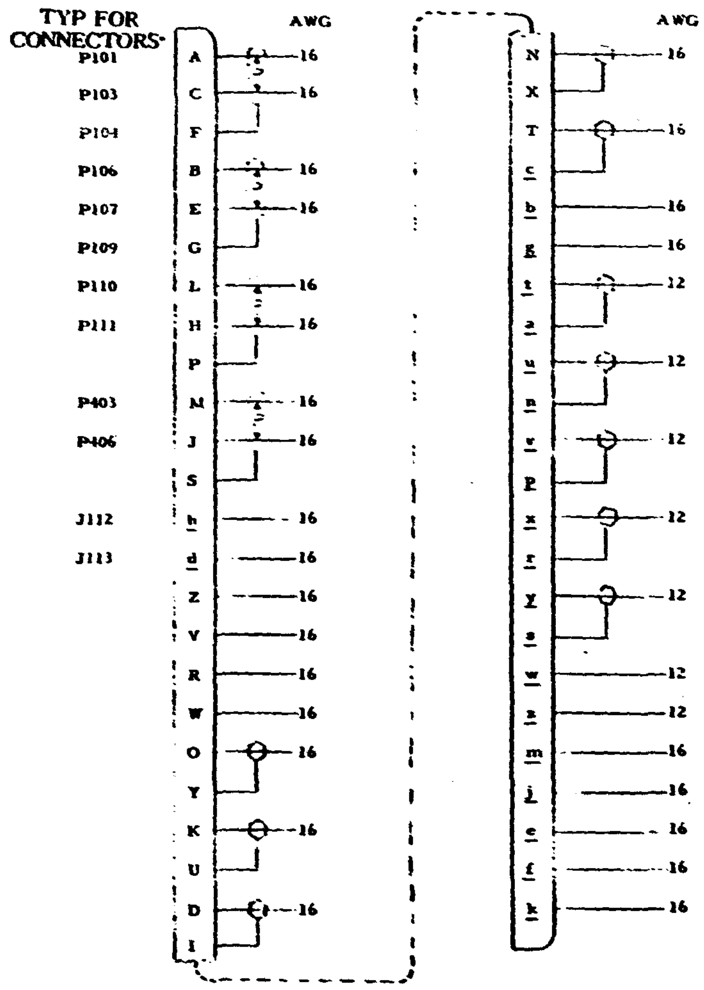


Figure 10-16. MS Insert Arrangement 36-7

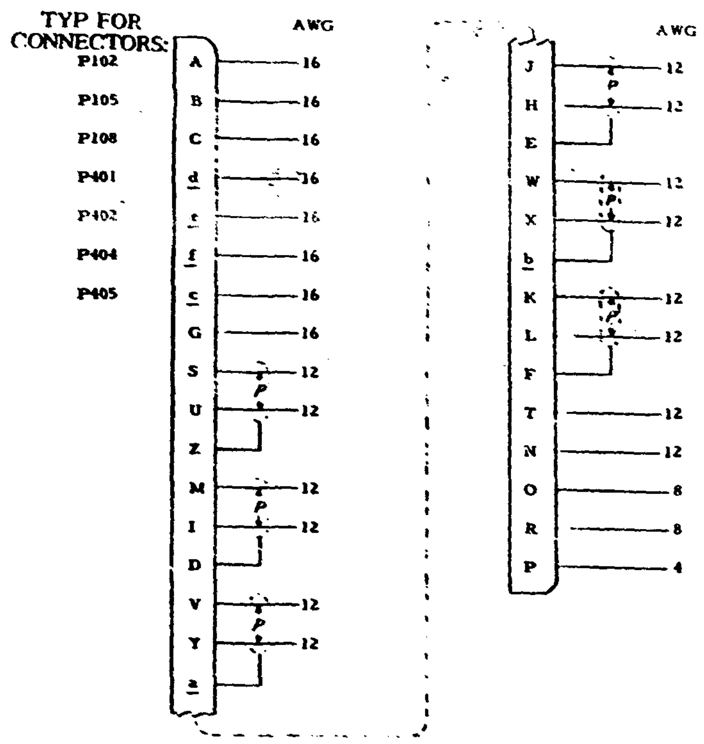


Figure 10-17. MS Insert Arrangement 36-9

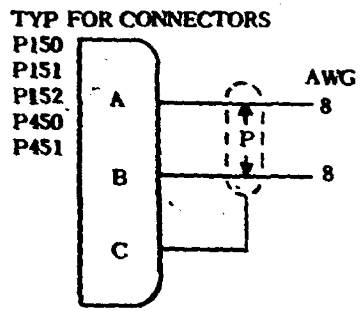


Figure 10-18. MS Insert Arrangement 28-3

10.4 ABRES-A GROUNDING NETWORK. Figure 10-19 shows the grounding network available at ABRES A.

In conjunction with the Booster/Payload electrical interface capability depicted by Figure 3-1, certain copperpaths can be made available from the payload to AGE via the booster wiring and booster umbilicals. Figure 10-13 shows the booster-cabling/payload-cabling interface capability. The number and size of conductors available for use by payload contractors are shown in Table 10-8.

Table 10-8. Booster Baseline Conductor Capability (Booster CDU to Booster Umbilical J-Box)

CONFIGURATION	TOTAL CONDUCTORS	CONDUCTORS AVAILABLE	ALLOW. SIGNAL CLASS
2 No. 1/0 Single conductor	2	2	ANY
6 No. 4 Single conductor	6	2	C
7 No. 8 Single conductor	7	3	C
48 No. 12 Single conductor	48	2	C
48 No. 14 Single conductor	48	7	C
48 No. 14 SSJ	14	5	C

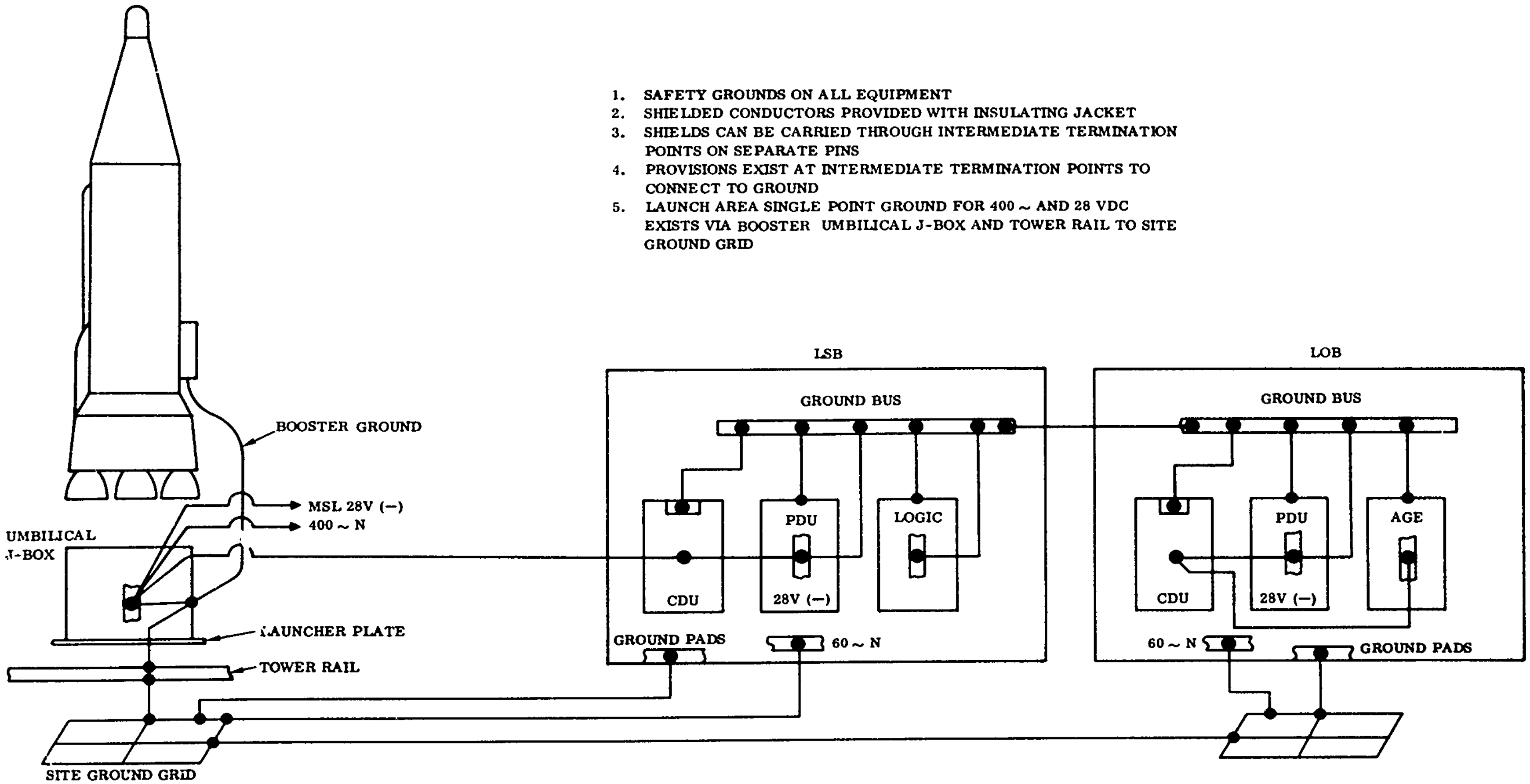
10.5 PAYLOAD COOLANT (FREON) SYSTEM. A system to supply Freon 21 for cooling payload electronics is installed on the UUT at Level 23 (Figure 10-20). Freon is transferred from this level to UUT boom Level 79 and thence to the payload by a flexible line. This line is ejected and retracted by means of the umbilical retraction system.

10.5.1 Capability

PARAMETER	VALUE
(1) Flow Rate	2 lb/minute at 40 psig 11.4 lb/minute at 155 psig
(2) Transfer Pressure	40-155 psig
(3) Capacity	120 pounds

10.5.2 Operation. Gas pressure is applied to the Freon storage vessel to effect the transfer. The pressure is supplied through a vessel which is recharged in place from a facility GN_2 source.

The flow of freon is controlled by means of a manually activated switch that controls a solenoid valve located on the UUT boom at Level 79.



1. SAFETY GROUNDS ON ALL EQUIPMENT
2. SHIELDED CONDUCTORS PROVIDED WITH INSULATING JACKET
3. SHIELDS CAN BE CARRIED THROUGH INTERMEDIATE TERMINATION POINTS ON SEPARATE PINS
4. PROVISIONS EXIST AT INTERMEDIATE TERMINATION POINTS TO CONNECT TO GROUND
5. LAUNCH AREA SINGLE POINT GROUND FOR 400 ~ AND 28 VDC EXISTS VIA BOOSTER UMBILICAL J-BOX AND TOWER RAIL TO SITE GROUND GRID

Figure 10-19. ABRES A Grounding Network

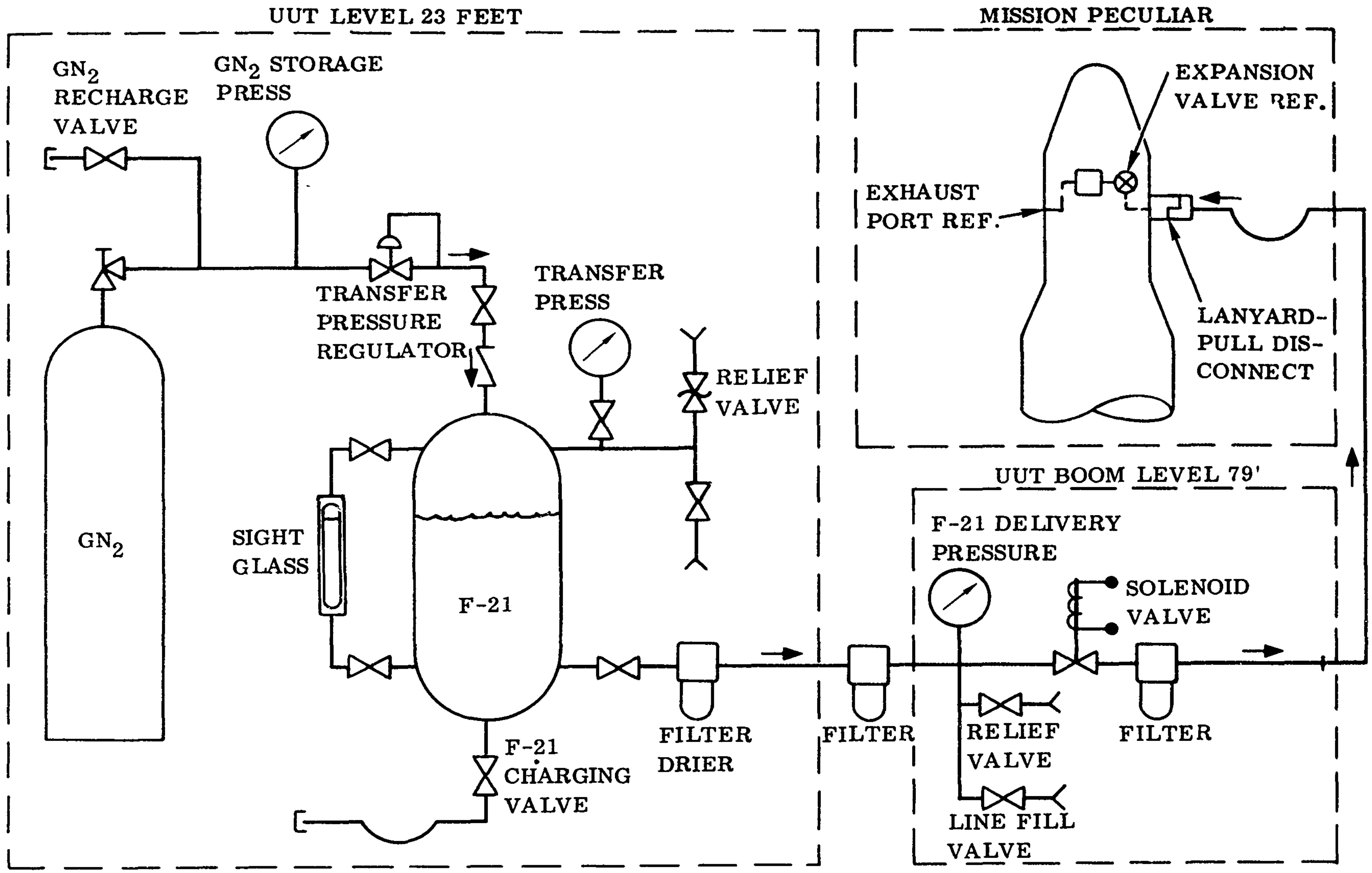


Figure 10-20. Freon Transfer System for Payload Cooling

The flow rates given in Paragraph 10.5.1 are based on the plumbing to the UUT boom interface point. Specific flow rates for each payload shall be provided by the payload contractor.

10.6 PAYLOAD AIR CONDITIONING SYSTEMS. There are two separate systems a-ailable, either may be connected to a duct, located near the launcher area, and routed to the UUT boom. Connection is then provided for each specific requirement from the UUT boom to the payload. The umbilical retract system is utilized in ejecting and retracting the payload air conditioning duct.

10.6.1 Payload Air Conditioner. This system is housed in a separate enclosure located alongside the LSB in Quad 1 and has the following capability:

PARAMETER	VALUE
Air Flow	30 lb/minute (nominal) 28 lb/minute (minimum)
Pressure	5 PSIG (nominal) 4.75 PSIG (minimum)
Temperature	48 ±3° F
Dew Point	10° F below ambient temperature
Cleanliness	Filtered thru a 25-micron filter.

10.6.2 Auxiliary Payload Air Conditioner. This system, is a separately controlled distribution system derived from the LSB air conditioning system. It is ducted to the UUT boom or to the launcher area and to a side-mounted auxiliary payload.

This system has the following capability:

PARAMETER	VALUE
Air Flow	45 lb/minute (minimum)
Pressure	24 inches of H_2O (0.5 psig)
Temperature	45° F to 80° F (adjustable)
Regulation	±1° F
Dew Point	+25° F (maximum)
Cleanliness	Filtered through a 25-micron filter

10.6.3 Instrumentation. Landline facilities for recording the temperatures and pressure of the conditioned air at the UUT boom are provided.

10.6.4 Air Conditioning Disconnects. The responsibility for selection and qualification of the disconnects rests with the payload contractor. However, Convair division has existing designs for the ducts and retraction lanyards for the following disconnects.

MANUFACTURER	IDENTIFICATION	
Lockheed MSC	P/N 69-81249	Airborne Half
	P/N 69-81253	Ground Half
	69-08023	Specification
Schulz Tool and Mfg. Co.,	P/N 10-461-401-3	Airborne Half
	P/N 10-461-251-1	Ground Half
	824D723	Spec Control Dwg

10.7 PAYLOAD PRESSURIZATION. A payload pressurization unit (PPU) is located on the service tower Level 75 to charge GN_2 and helium systems on certain payloads. The PPU contains two GN_2 and one helium systems. All are pressure regulated.

The PPU has the following capability:

PARAMETER	VALUE		
	GN_2 #1	GN_2 #2	Helium
Pressure (psig)	0-5000	Common reg with GN 1	0-5000
Relief Valve	3630 to 4999	2810 to 4059	2810 to 4059
Cleanliness	5-micron filter (15-micron absolute)		
Hose Mating Connector	MS24392C4	MS24392C4	MS21900C4
Flow	Through 0.02 orifice		

10.8 BOOSTER SERVICE TOWER. Each of the three launch pads is equipped with a moveable vertical gantry type service tower for erection, checkout, and servicing of the booster and payload (Figure 10-21). Weather protection is provided from level 66 to level 102.

10.8.1 Service Tower Platforms (Figures 10-22 through 10-26). Platforms are provided at tower stations 12, 21, 30, 66, 75, 84 and 93. These platforms swing out (except) at station 93 which folds up) to allow clearance for moving the tower in preparing for loading exercises and launch. Access to side mounted payloads is provided from stations 21 and 30. Access to nose mounted payloads is available from levels 66, 75, 84, and 93. These platforms provide 360-degree access to the payload and booster.

The basic structural interface for level 66, 75, and 84 provides clearance for 100-inch payloads plus approximately 8-inch clearance for tower motion and positioning. Inserts are provided to adapt to specific payload requirements. Station 93 provides clearance for a 48-inch diameter payload. Inserts are presently available to adapt Stations 75 to 48-inch and 84-inch payloads, Station 84 to 32-inch, 48-inch, and 84-inch payloads, and Station 93 to 24-inch payloads.

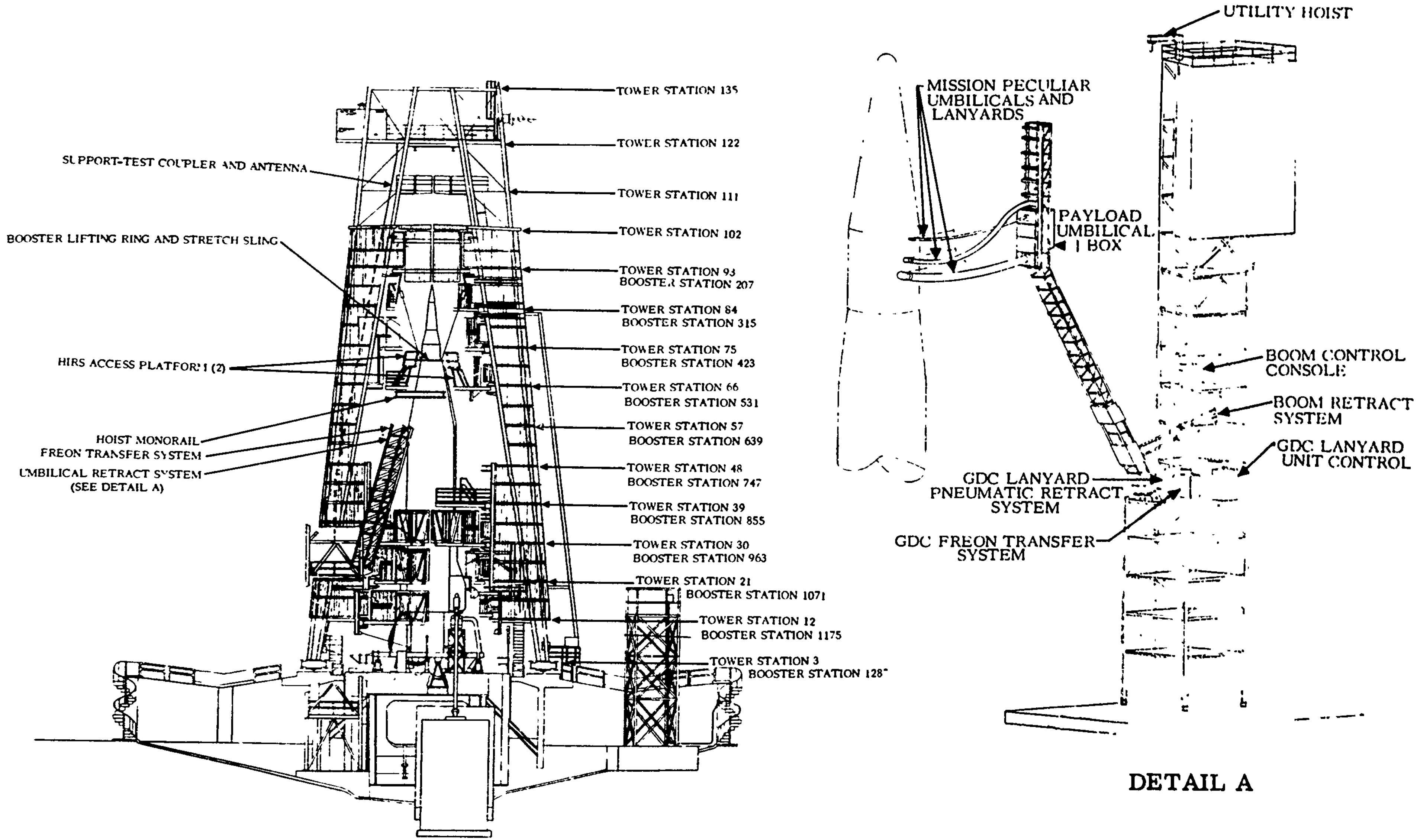


Figure 10-21. Booster Service Tower

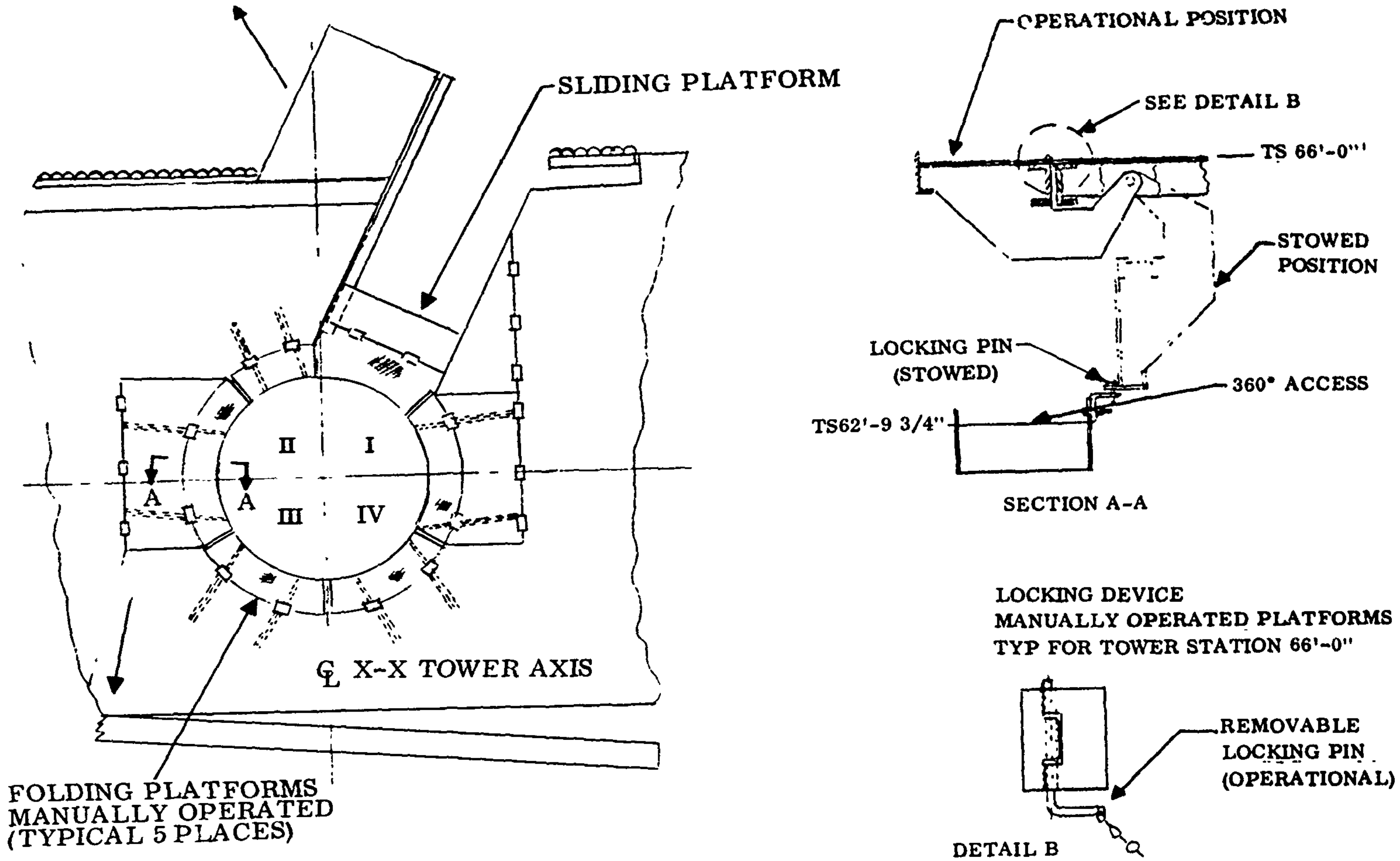


Figure 10-22. Tower Station

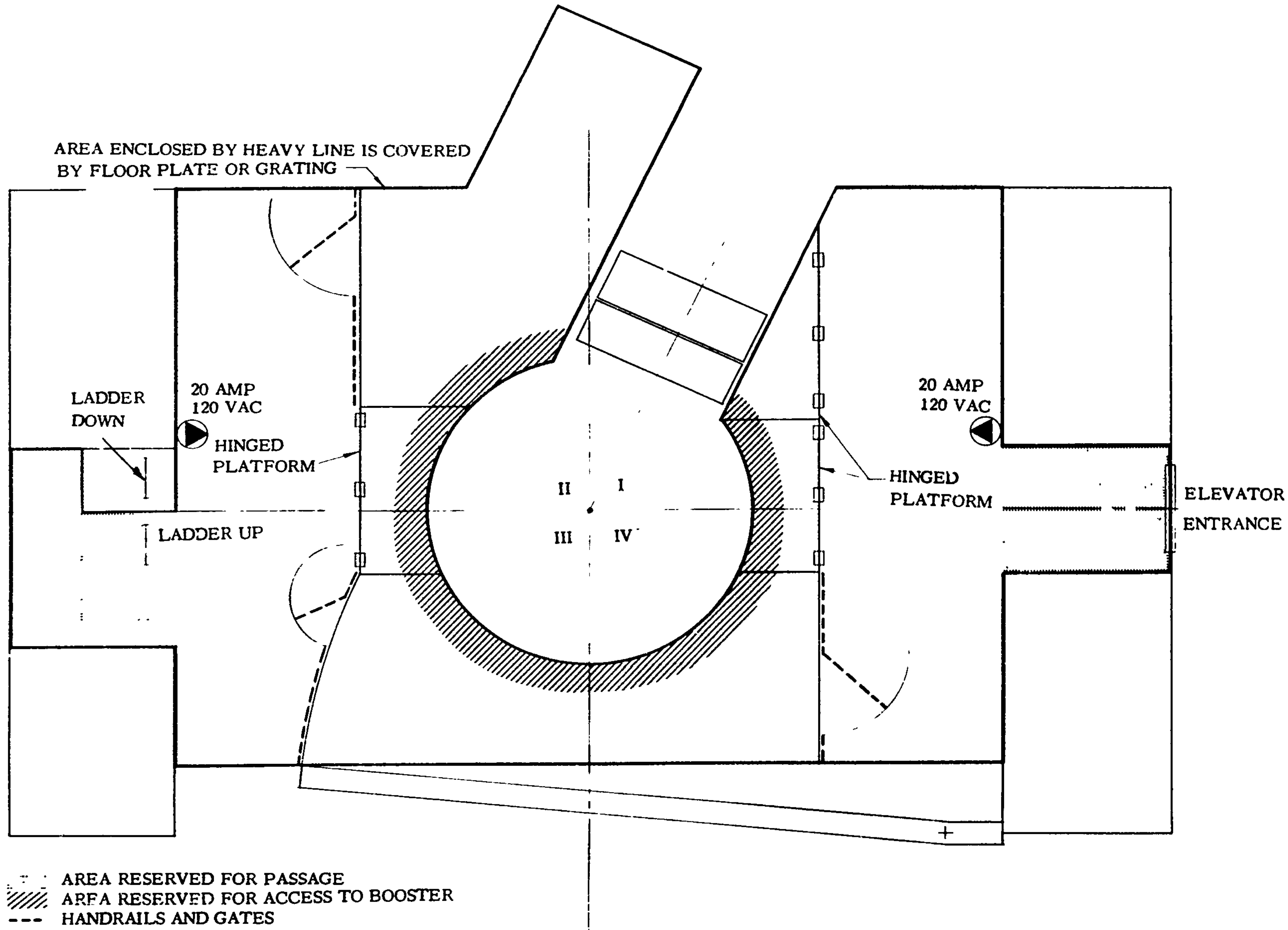


Figure 10-23. Useable Floor Space Areas, Tower Station 66

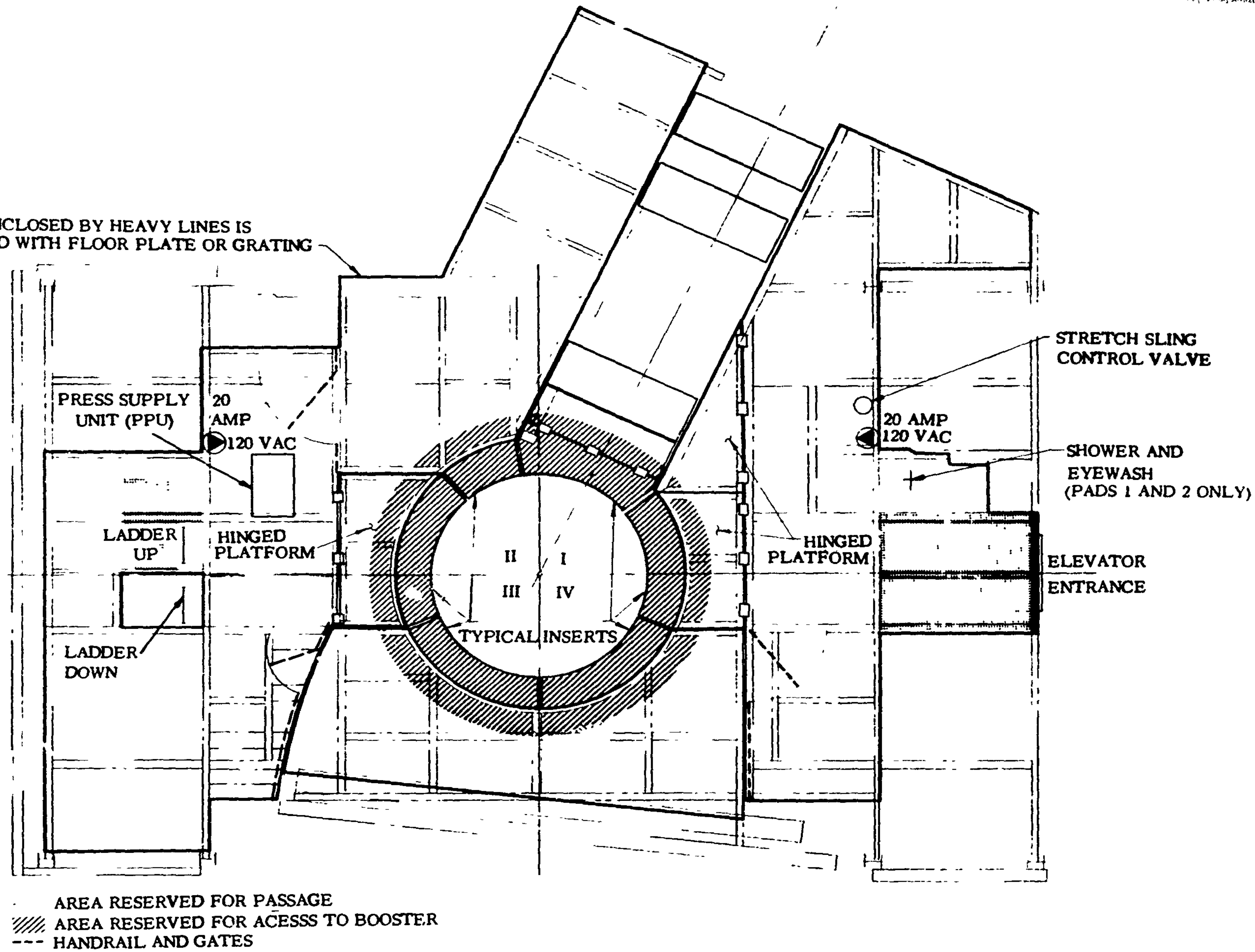


Figure 10-24. Useable Floor Space Areas, Tower Station 75

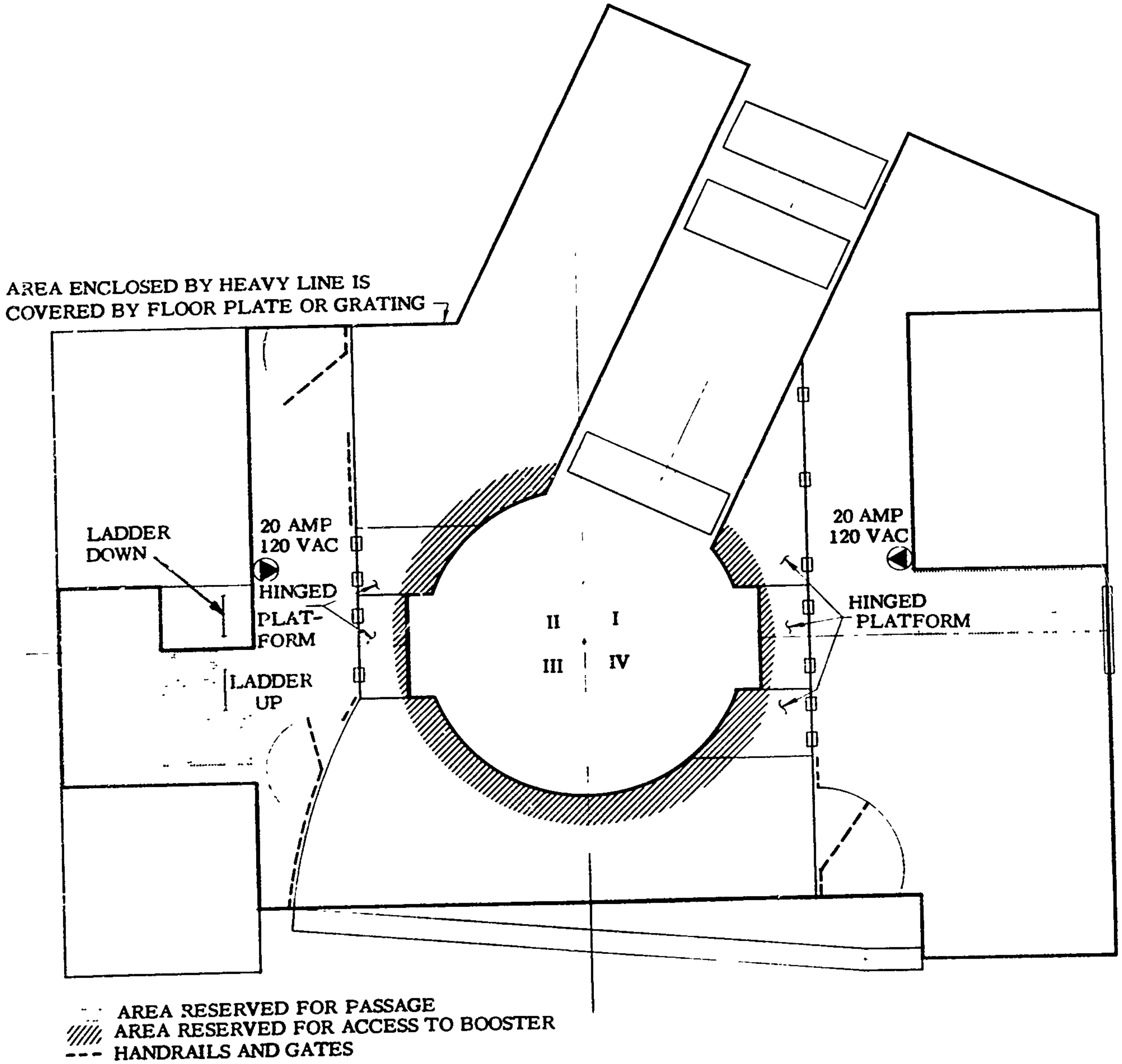


Figure 10-25. Useable Floor Space Areas, Tower Station 84

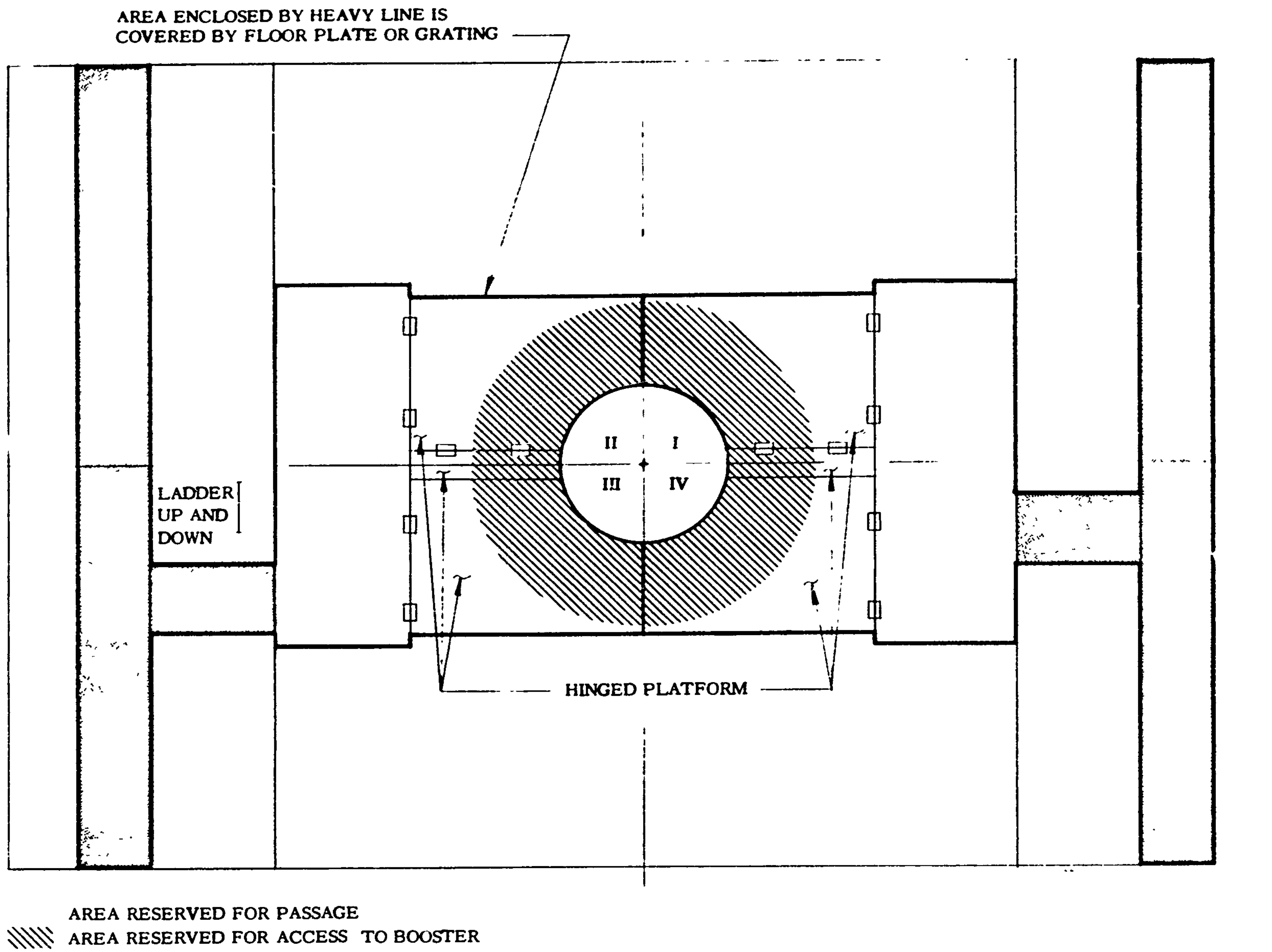


Figure 10-26. Useable Floor Space Areas, Tower Station 93

10.8.2 Service Tower Utility Hoist (Bridge Crane). A 10-ton bridge crane type hoist is located below level 122. The bridge crane is capable of traveling the following distances from the intersection of the X and Y axis (center line of booster):

a. 19 feet of travel (X axis, Quads III and IV).

b. 12 feet of travel (X axis, Quads I and II).

c. 1.3 feet of travel (Y axis, Quads II and III).

d. 1.9 feet of travel (Y axis, Quads I and IV).

Maximum hook elevation = Tower Station 112-0.

Maximum travel of hook = 112 feet.

10.8.3 Monorail Hoist. A 3000 pound monorail hoist is located below the station 66 platform for installation and servicing side-mounted auxiliary payloads. This hoist is accessible to Quads I, III, or IV.

10.8.4 Access at Service Tower Base. Access on the pad is constrained by permanently installed booster trailer alignment rails. The alignment rails are approximately 20 inches high. The aft alignment rails are approximately 14 feet long and the forward rails are approximately 40 inches long. The aft end of the forward rails is located 718 inches forward of the booster centerline and the aft end of the aft rails is located 121 inches forward of booster centerline. The rails are symmetrically installed about the X axis, the aft rails 139 inches apart and the forward rails 77 inches apart (see Figure 10-27).

10.9 GROUND POWER CAPABILITY. Sixty cycle power is furnished to ABRES A at 4160 vac over a 3 phase delta system. The system is loaded to approximately 75 percent of capacity. This source is transformed and distributed at the following voltages in the LOB:

466 ± 10% vac, 3 phase delta

116/201 ± 10% vac, 3 phase, 4 wire wye

114/197 ± 10% vac, 3 phase, 4 wire wye

113.5 ± 10% vac, 1 phase

118 ±5% vac, 1 phase

115/200 vac, 3 phase, 400 Hz

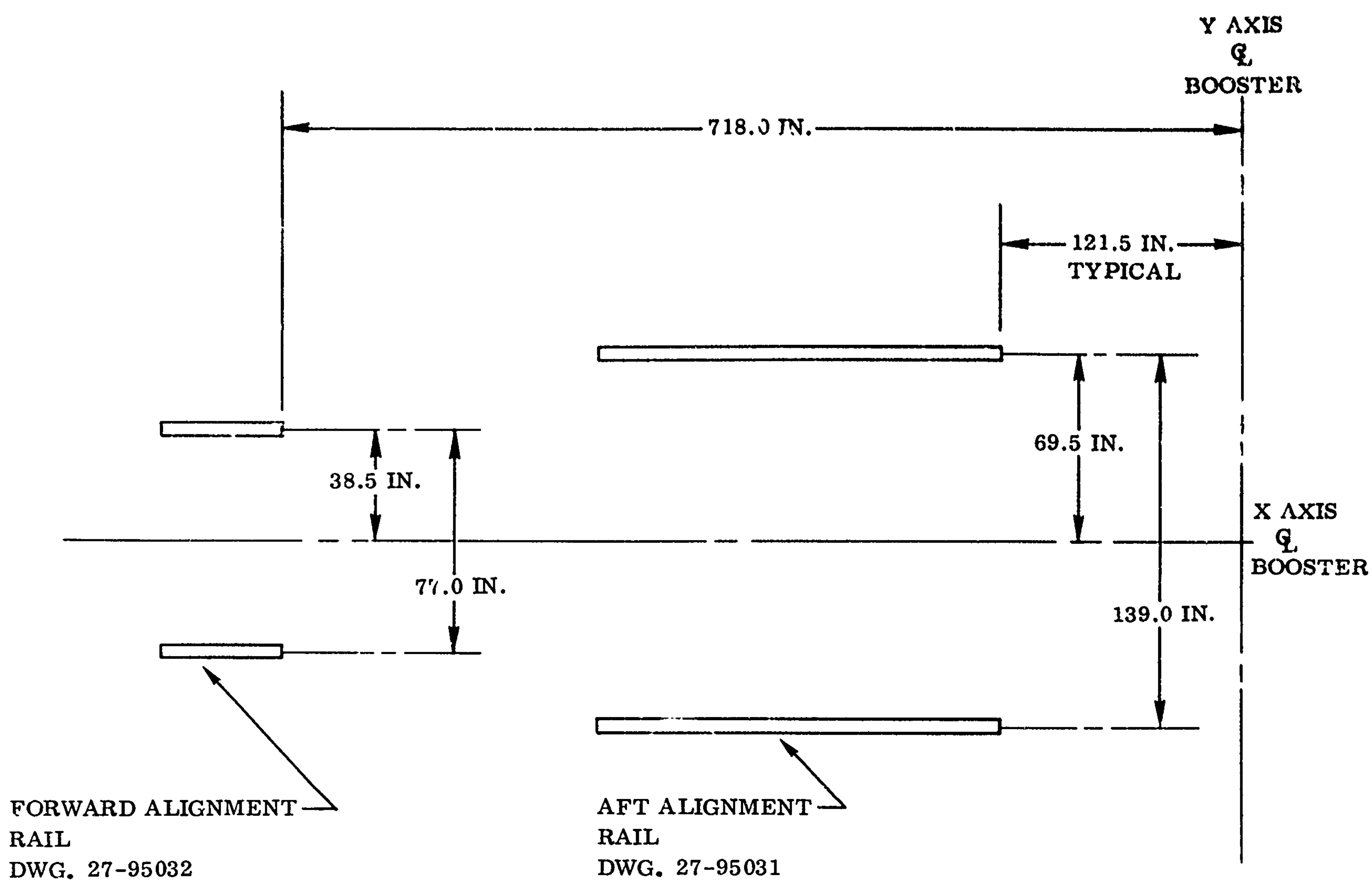


Figure 10-27. Booster Trailer Alignment Rails

The following voltages are distributed at each of the three LSBs:

468 ±10% vac, 3 phase delta

117/212 ±10% vac, 3 phase, 4 wire wye

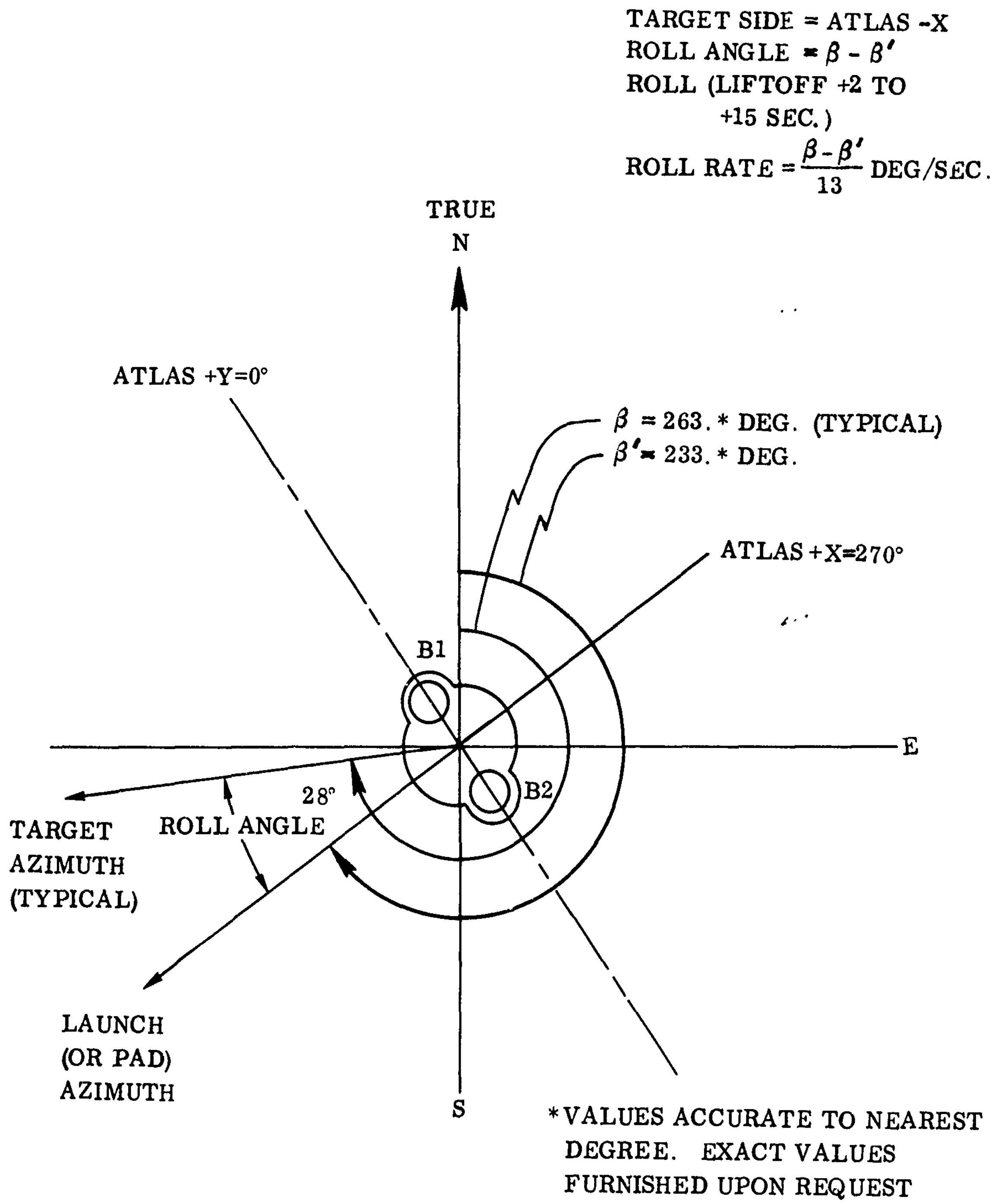
In addition, 116/201 ±5% vac, 3 phase, 4 wire wye is available at the Pad 2 LSB.

A 28 ±4 vdc power source is available in the LOB and LSB. This source has a regulation of ±1%, 1% rms ripple and a response time of 0.1 second. This 28-vdc power is backed up by an emergency battery that will supply "shut down" power in case of a general power failure.

The payload contractor is required to coordinate payload power requirements with Convair to ensure that existing power sources are sufficient to meet booster and payload requirements.

10.10 BOOSTER PAD ALIGNMENT AND PROGRAMMED ROLL. The booster orientation and alignment on an ABRES pad is shown in Figures 10-28 and 10-29. Each ABRES pad is equipped with a collimator installation used for precise alignment of the mated booster and payload. Figure 10-30 shows a typical collimator installation.

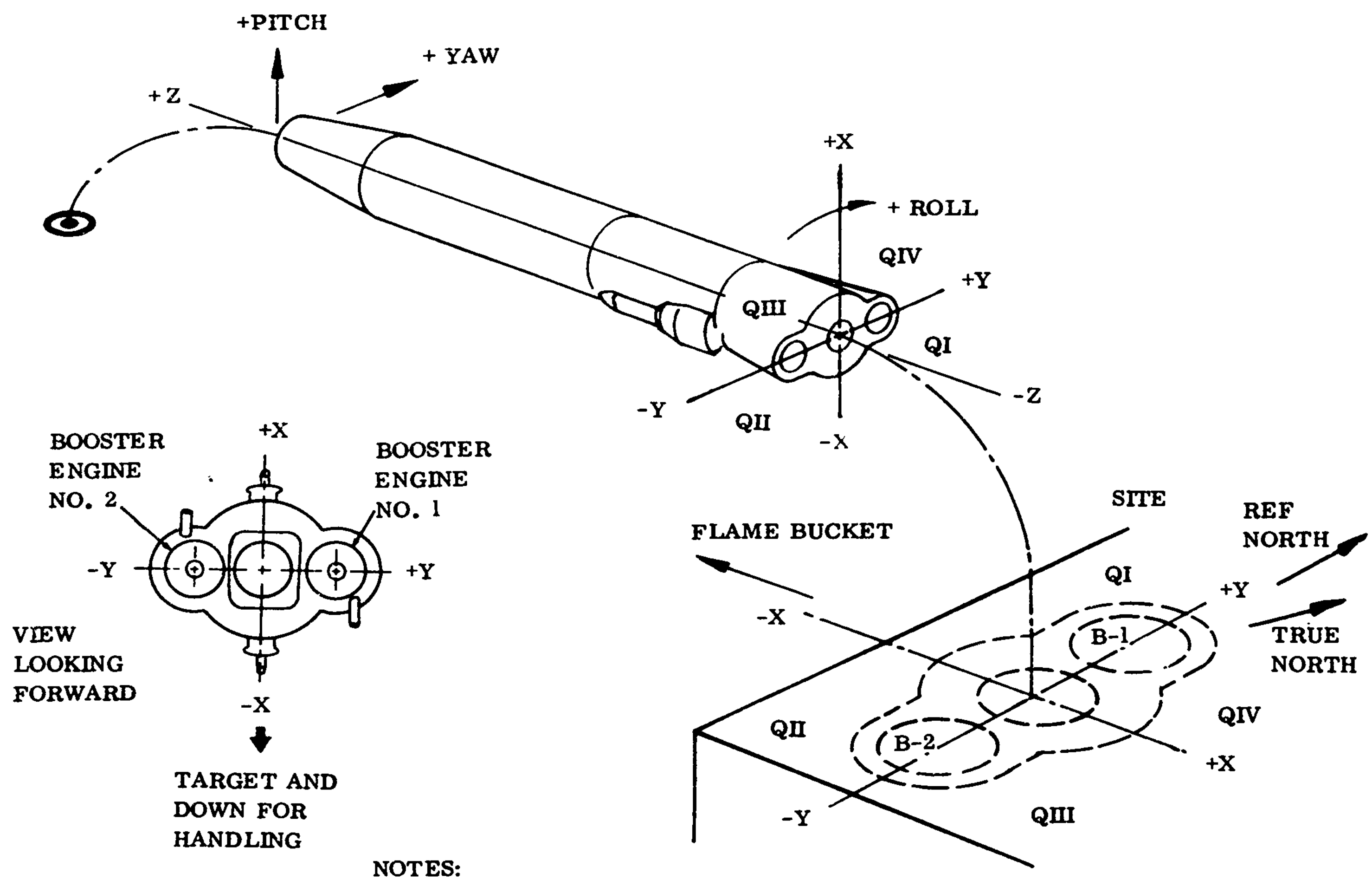
10.11 TYPICAL ENVIRONMENT AT ABRES -A. Based on an 8-year summary, the prevailing winds are 5 to 10 knots from a north westerly direction with peak gusts up to 40 knots. Temperatures range from a maximum of 99°F to a minimum of 30°F, with mean maximum of 66°F and mean minimum of 49°F. The mean relative humidity is 78 percent, precipitation varies from a low ot 0.02 inches in June and July to a mean maximum of 2.7 inches per month in February.



VIEW LOOKING DOWN ONTO ABRES A

GEODETIC LATITUDE = 35° N*
LONGITUDE = 121° W*
BOOSTER ROLL CAPABILITY AS BUILT = APPROX. ±8° /SEC MAX. ROLL RATE
APPROX. ±100° TOTAL ROLL

Figure 10-28. E/F Booster Alignment on Launcher and Roll in Flight



NOTES:

1. Movements in flight are identified as positive for nose up pitch, nose right yaw, and clockwise roll when viewed from aft.
2. Trailers, jigs, towers, etc., securing flight vehicle take 's and sign of secured flight vehicle.
3. The -X axis is down for handling and after pitch program start. During vertical portion of flight the -X axis is aligned parallel with flight azimuth and points toward target.

Figure 10-29. Booster Sign Convention and Coordinate Axes

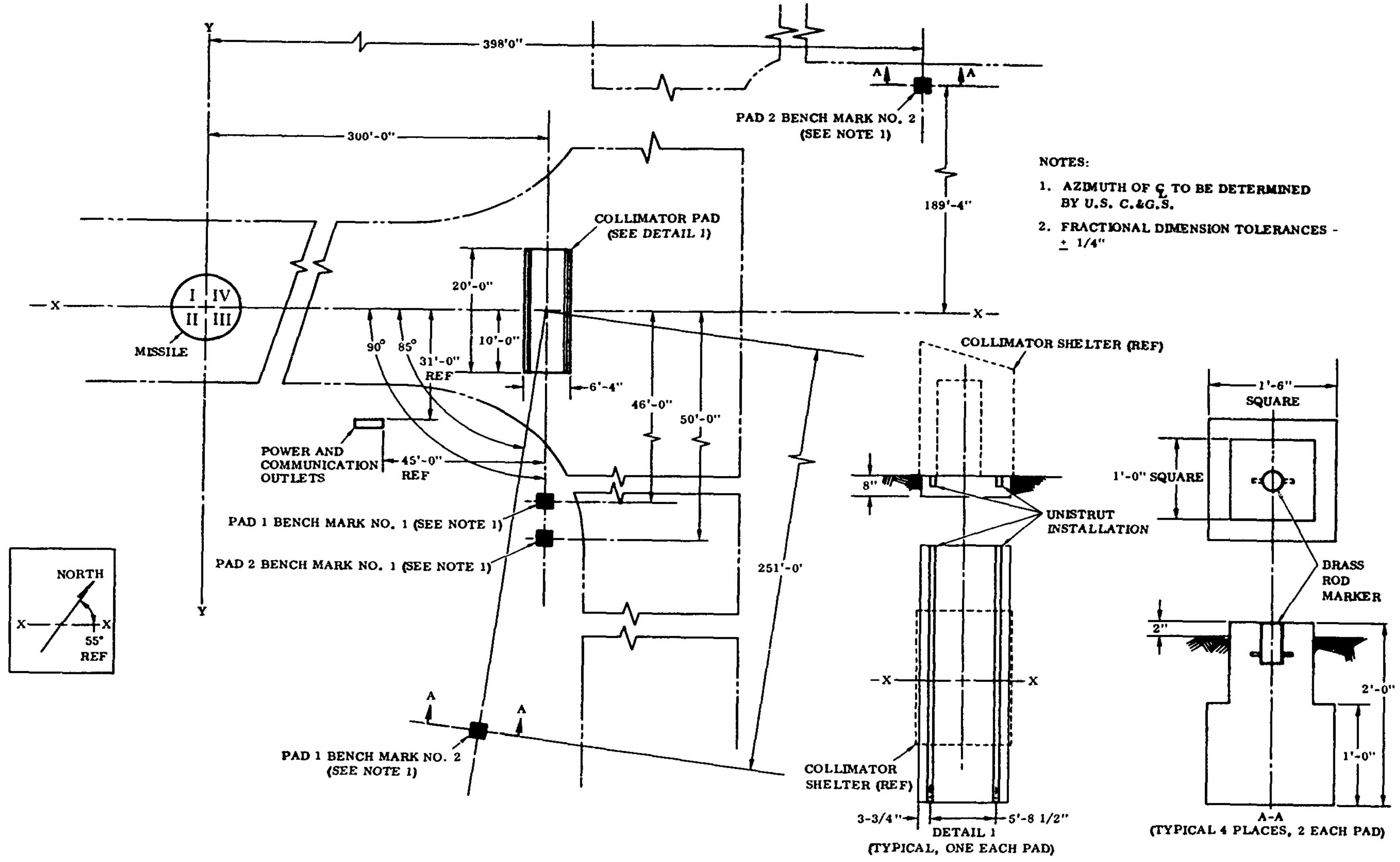


Figure 10-30. ABRES A Collimator Installation

SECTION 11

LAUNCH SITE CHECKOUT AND COUNTDOWN

A typical launch site sequence is shown in Figure 11-1. As shown the booster is usually "on-stand" at least 5 days prior to any payload mating. This period is required for booster checkout which involves the forward tank areas and access to the forward bulkhead.

The payload is installed on the booster between X-30 and X-7 days. The specific installation time is determined by the checkout time required for preparation for integrated testing. Generally, payloads are removed for the Wet Dress Rehearsal and reinstalled at approximately X-3 days.

11.1 INTEGRATED TESTING. Intergrated testing of the booster and payload is performed to ensure proper integration of all interfaces. Integrated testing involves activating all electrical systems required during countdown, launch, and flight. A simulated countdown is performed and the umbilicals (booster and payload) are ejected. The test then continues through a sequence which generates booster in-flight discretes and commands including payload separation commands. All pyrotechnics are simulated by devices (fuses, circuit breakers, etc) to verify that the proper commands were issued and received. It is desirable that the booster/payload "In-flight Disconnect" be separated during these tests.

Payloads shall be equipped with bypasses around baroswitches, acceleration switches, etc, so that the payload can generate inflight discretes and/or events. Pyrotechnic simulators shall be provided for integrated testing.

An Electromagnetic Compatibility (EMC) test is performed on the first of a series of payloads. This test is conducted either during the Wet Dress Rehearsal or a special booster tanking is performed for the EMC test.

The payload is installed on the booster between X-30 and X-7 days. The specific installation time is determined by the checkout time required for preparation for integrated testing. Generally, payloads are removed for the Wet Dress Rehearsal and reinstalled at approximately X-3 days.

11.2 LAUNCH COUNTDOWN. The booster launch countdown is the period of time in which final system checks are performed, the subsystems are commanded to their flight modes, and the booster engines are ignited. Figure 11-2 is a time-oriented countdown bar chart divided into three major time periods: airborne electrical checkout, terminal countdown, and commit sequence.

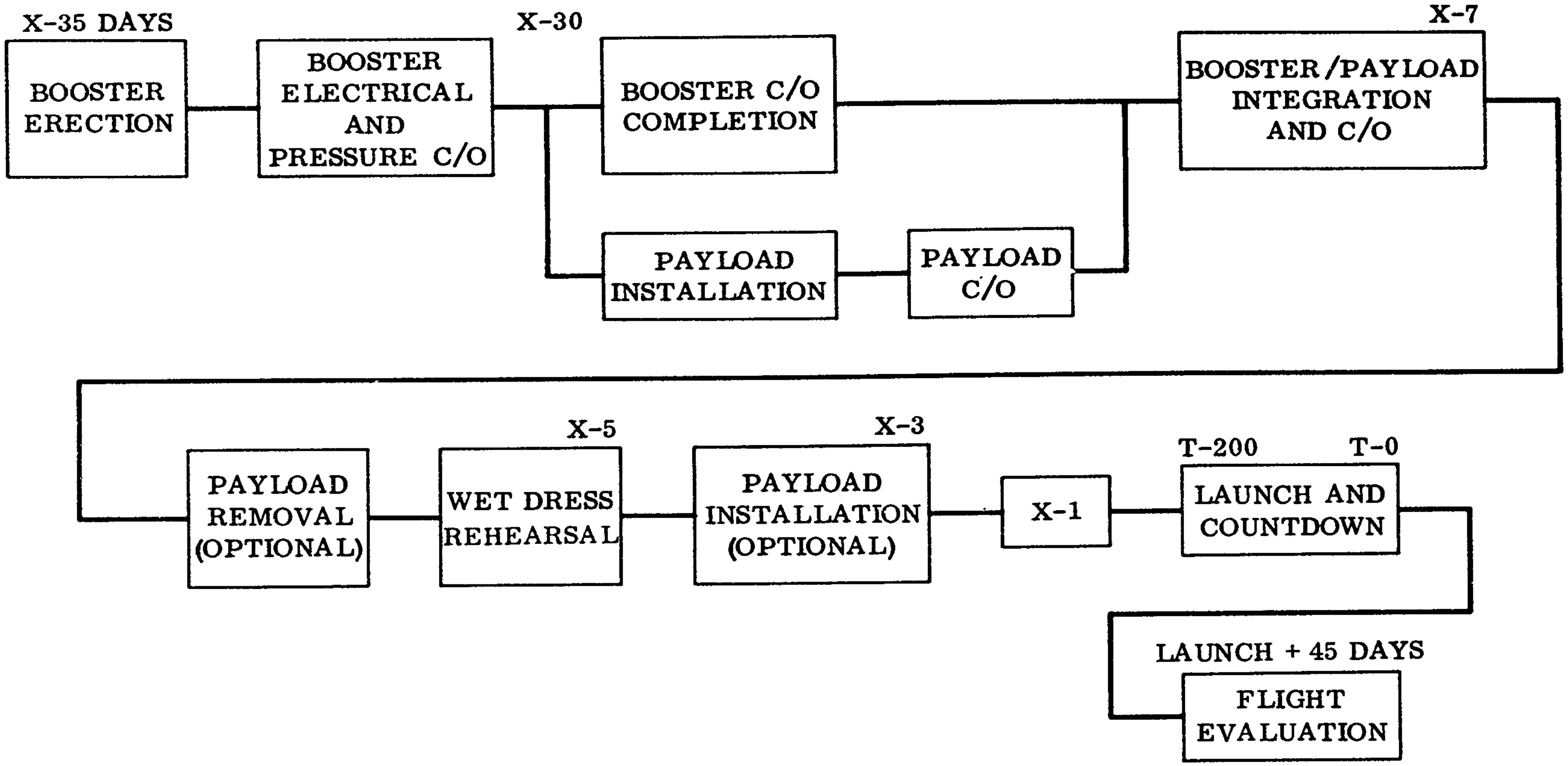


Figure 11-1. Launch Site Sequence of Operations

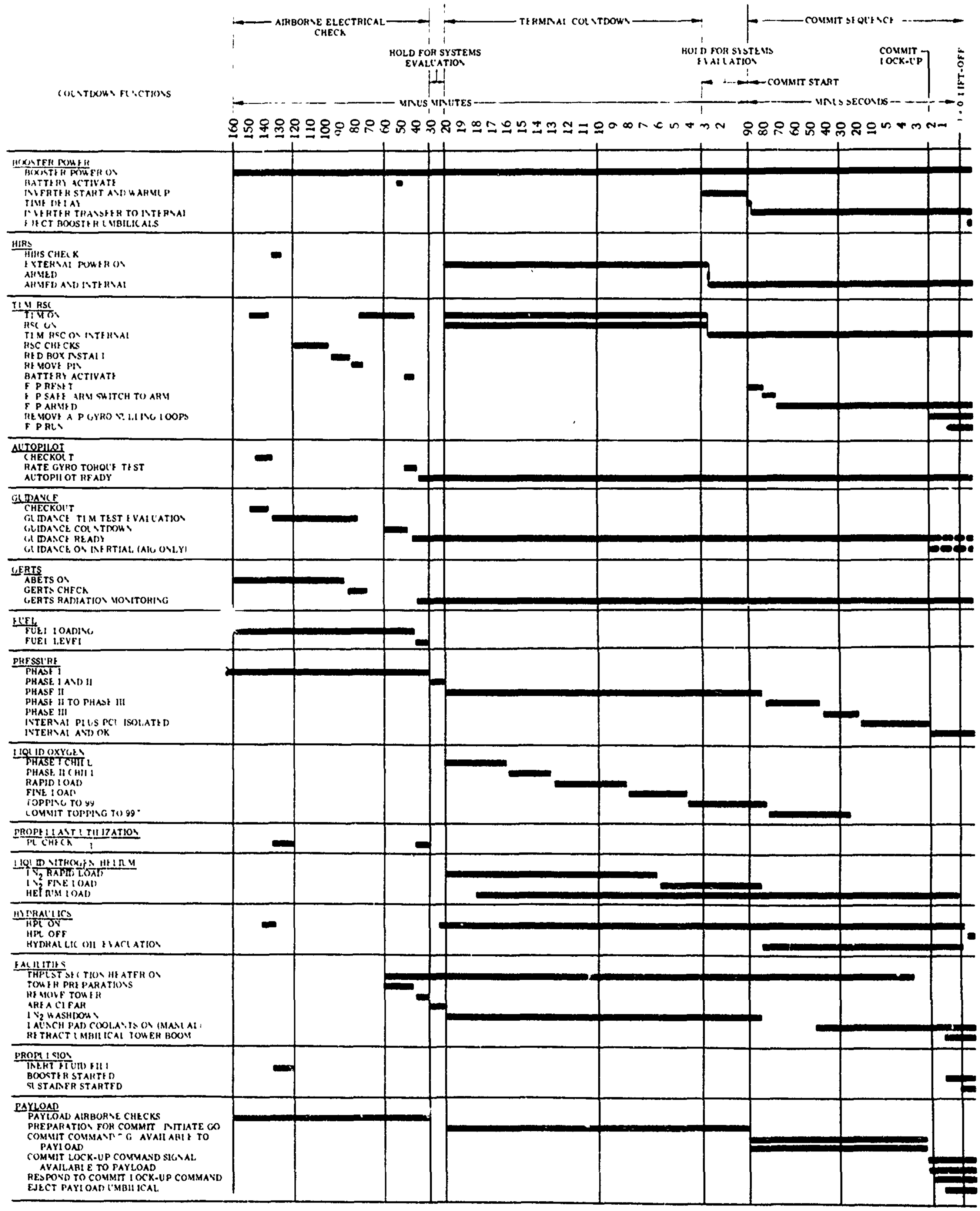


Figure 11-2. Booster Launch Countdown

11.2.1 Airborne Electrical Checkout. During airborne electrical checkout, booster power is turned on and the following checks are performed:

a. Telemetry, autopilot, and guidance checkouts.

b. GERTS checkout, range safety checkout, and arming.

c. Final fuel loading and service tower removal.

Throughout this period, 115 vac, 400-cycle and 28 vdc power is available on the booster busses. In addition, the booster autopilot programmer is operated and the discrete signals that the programmer normally generates in flight are generated for checkout purposes. Personnel have access to the Launch Service Building (LSB) and to the launcher area during this period.

11.2.2 Terminal Countdown. During terminal countdown, final preparations are made to enable committing the booster to launch. Liquid oxygen is loaded during this period, and personnel are excluded from the LSB and launch area.

The booster is controlled by semiautomatic logic. This logic requires a payload "GO" signal to complete the summary enabling the commit or final sequence. This signal may be generated by the payload contractor at any time prior to approximately T-3 minutes. The logic interface is such that a continuous, isolated, electromechanical circuit closure capable of handling one ampere d-c inductive load at 28 vdc should be provided by the payload contractor. Interruption of this circuit closure at any time prior to commit will prevent the start of the Commit Sequence. Interruption after the start of commit will have no effect on continuation of the sequence. The point of interface for this "GO" signal should be at the payload contractor's equipment.

At the completion of terminal countdown, the booster is capable of an extended hold period for systems evaluation, range clearance, etc.

11.2.3 Commit Sequence. The final phase of the launch countdown is designated the "Commit Sequence." This is an automatic sequence initiated manually. The sequence can be initiated only if the systems, as summed by the launch logic, are in a "Ready" or "GO" status. The Commit Sequence issues final commands and verifies events required to transfer booster/payload systems from a ready condition to the launch and flight conditions. During the Commit Sequence all booster systems are automatically transferred from ground control to booster internal control. Manual stop or cut-off capability is provided up to approximately T-2 seconds.

The following launch logic command signals are available for payload contractor use during the Commit Sequence.

a. Commit Start (manual initiation of automatic sequence).

b. Commit Lock-up (booster systems ready for engine ignition and manual stop inhibited).

c. Not Commit Lock-up (prior to systems ready, stop pushbutton enabled).

The preceding logic signals are available as isolated relay contacts. Commit Start and Commit Lock-up contacts are MS25269D-1 relays rated at five amps for a resistive load. A second Commit Lock-up and the Not Commit Lock-up contacts are a MS2527D-1 relay rated at 10 amps for a resistive load. The interface point for these signals is at the payload contractor's equipment.

For payloads utilizing inertial guidance or attitude control system, a command and response capability has been provided within the launch logic system.
The command, a relay closure capable of delivering one amp at 28 vdc, is issued at Commit Lock-up (approximately T-3 seconds). A response to this command must be provided within two seconds. When boosters are equipped with inertial guidance the countdown is aborted if this response is not received. For boosters equipped with radio guidance, the countdown is recycled to a pre-commit state if the response is not received within the 2-second time limit.

The logic interface for this payload "GO" signal is such that a continuous, isolated electromechanical circuit closure capable of handling one ampere d-c inductive load at 28 vdc should be provided by the payload contractor. The point of interface is at the payload contractor's equipment.

Payload response functions, if not required, may be bypassed prior to the start of booster launch countdown by selection of a switch position on the booster AGE.

The final launch countdown action of demating the umbilical cables from the payload may be accomplished at Commit Lock-up or at booster ignition by pre-selection of a switch position on the booster AGE in the LSB. The umbilical cable eject mode switch is not operated during countdown, but must be preselected to meet established payload system requirements.

SECTION 12
PAYLOAD INTEGRATION REQUIREMENTS

This section defines the data required by Convair to properly integrate a payload on the Atlas E/F booster. The schedule for delivery of data is always specified by applicable contracts. However, in all cases the data is required before design changes can be started on existing Atlas E/F boosters.

Tables 12-1 through 12-6 identify the type and scope of data required from payload contractors for each different payload.

Table 12-1. Payload Dynamic Characteristic Data

TYPE OF DATA	SCOPE OF DATA
Mass Properties	*1. Weight. The weight of the payload shall be specified a. At lift-off (spacer, ballast, shroud and re-entry vehicle). b. At fairing separation (spacer, ballast and re-entry vehicle). c. After separation (re-entry vehicle and attached hardware). d. At re-entry (re-entering vehicle). *2. Center of Gravity. The center of gravity of the payload shall be specified in three orthogonal coordinates parallel to the booster roll, pitch and yaw axes. A drawing or diagram of the vehicle and spacer is desirable. The location of the c.g. should be specified in booster coordinates. a. At lift-off (spacer, ballast, fairing and re-entry vehicle). b. At fairing separation (spacer, ballast and re-entry vehicle). c. After separation (re-entry vehicle and attached hardware). d. At re-entry (re-entering vehicle). *3. Moments of Inertia. The moments of inertia of the payload shall be specified about axes through the payload c.g. which are parallel to the booster roll, pitch and axes. a. At lift-off (spacer, ballast, fairing and re-entry vehicle).

*Trajectory Targeting Input Report

Table 12-1. Payload Dynamic Characteristic Data (Contd)

TYPE OF DATA	SCOPE OF DATA
	b. At fairing separation (spacer, ballast and re-entry vehicle). c. After separation (re-entry vehicle and attached hardware). d. At re-entry (re-entering vehicle). *4. The mass distribution data of the re-entry vehicle versus re-entry vehicle station shall be presented.
Structural Characteristics	1. Spring ratio of structure, elastic deflection constants, shear stiffness, dynamic model, bending moments and shear loads at booster/payload interface, and limitations (acoustic, shock, acceleration, temperature, and bending moments). *2. Stiffness parameters, EI and KAG data versus re-entry vehicle station, shall be presented.
Mission Peculiar Impulses	*The magnitude, direction, time, time duration and point of application to the payload and booster shall be given for all forces which impart motion or velocity to the payload. If the impulse imparted to the payload is accomplished over a short time interval, the resultant velocities imparted to the payload and booster as components parallel and perpendicular to the roll axis of the booster shall be specified. a. Separation System b. Deployment System c. Attitude Control System (pitch, yaw and roll impulses).
Separation Characteristics	Fairing ejection characteristics and trajectory, velocity of payload relative to booster, separation-spring constant and compressed length, force application points, force vs time curve, separation plane configuration and clearances, and minimum separation requirements between booster and payload during midcourse and re-entry.
Payload Propulsion and Attitude Control	Impulse, thrust orientation, jet expansion, complete ballistic characteristics, time of activation, and effects on payload separation. *Trajectory Targeting Input Report

Table 12-2. Aerodynamic Characteristics Data

TYPE OF DATA	SCOPE OF DATA
Aerodynamic Data	1. Aerodynamic limitations on payload, i.e., extent of internal pressure requirement at adapter, cross-flow venting problems between payload and adapter. 2. Winds aloft considerations and limitations due to payload configuration. 3. Type of trajectory and range to be flown, and target location. *4. Ascent Aerodynamic Characteristics. The drag coefficient (minus base drag), at zero angle of attack versus Mach number shall be given. The slope of the aerodynamic normal and side force coefficients with angle of attack and the center of pressure shall be presented versus Mach number. The aerodynamic reference area shall be specified. These characteristics shall be specified for the combined re-entry vehicle and spacer combination, i.e., the entire configuration assembly furnished by the R/V contractor. *5. Re-entry Drag. The drag coefficient versus Mach number (and versus altitude if applicable) at zero angle of attack for the re-entry vehicle shall be specified. The aerodynamic reference area shall be given. The effect of ablation on the drag coefficient and reference area, versus Mach number (and versus altitude if applicable). *6. Ablation Weight Loss. The ablation weight loss of the re-entry vehicle versus Mach number (and versus altitude if applicable) shall be specified. These characteristics should be presented as the ratio of instantaneous weight versus the independent variable. *7. Ballistic Coefficient. The ballistic coefficient (W/C_dA) of the payload shall be specified at hypersonic Mach number together with the Mach number at which it was determined. *8. Fairing Ejection Trajectory. The trajectory of the fairing (if applicable) relative to the booster shall be presented. Hingepoints, forces and attitudes of the shroud vs time, in the vicinity of the booster, shall be presented. *Trajectory Targeting Input Report

Table 12-2. Aerodynamic Characteristics Data (Contd)

TYPE OF DATA	SCOPE OF DATA
Configuration Drawings	*Drawings showing the re-entry vehicle configuration, shape, dimensions and protrusions into the mounting spacer shall be presented.
Tolerances	*Tolerances shall be specified for all mission peculiar event times, attitude control impulses, separation delta velocities, separation tip-off rates, etc.
Event Times	*The event/time sequence for all payload-initiated events (i.e., fairing ejection, separation, pitch, de-pitch, spin-up, deployment, etc.) shall be given referenced to vernier engine cutoff or the signal which is furnished as reference time to the payload mechanism.
	*Trajectory Targeting Input Report

Table 12-3. Interface Data

TYPE OF DATA	SCOPE OF DATA
Mechanical Interface	1. Base diameter of payload interface.
	2. Structural attachments at payload interface.
	3. Required accessibility to underside of payload in mated condition.
	4. Comprehensive drawings of underside of payload from standpoint of protrusions within the Atlas adapter.
	5. Extent of equipment remaining with adapter after payload separation.
	6. Degree of environment control required at base of payload.
	7. Payload pressurization and fueling system connector type and location.
	8. Payload/adapter venting requirements.

Table 12-3. Interface Data (Contd)

TYPE OF DATA	SCOPE OF DATA
Electrical Interface	1. Power and signal characteristics at payload interface. 2. Discrete signal requirements at payload interface, and equivalent circuit loading the discrete. 3. Type of wire required for test and operational purposes, shielded, twisted, etc., including end-to-end maximum resistance and capacitance and special current requirements. (See Table 12-4.)

Table 12-4. Payload Aerospace Ground Equipment (AGE) Data

TYPE OF DATA	SCOPE OF DATA
AGE Cabinets Data	1. Quantity of cabinets. 2. Sizes of cabinets. 3. General location required for each cabinet. 4. Cabinet mounting provisions. 5. Cabinet grounding and bonding requirements. 6. Cabinet cooling air. 7. Access space to cabinets required for work area, door swing, slideout panels, etc. 8. Cable entry provisions and terminal board types in cabinets and/or interface receptacle locations and types. 9. 28 vdc, 115 V, 400 Hz and 115 V, 60 Hz power requirements and characteristics of power for each cabinet. 10. Cabinet weight.

Table 12-4. Payload Aerospace Ground Equipment (AGE) Data (Contd)

TYPE OF DATE	SCOPE OF DATA
Payload Electrical Conductor Data	1. Payload system schematic showing all conductors required between payload equipments and payload, terminal board position or receptacle pin assigned to each conductor, electrical characteristics of each conductor including maximum end-to-end resistance, shielding, capacitance, etc., and spare conductors. 2. Classification assigned to each conductor based on the following signal classifications: Class A - A signal that generates noise to other circuits and is not susceptible to outside noise. Class A signals shall be grouped and routed separate from Class B and A (Pulse). Class B - A signal that does not generate [illegible] susceptible to outside noise. Class B signals shall be grouped and routed separate from Class A and A (Pulse). Class C - A signal that does not generate noise and is not susceptible to noise. Class C signals may be routed with Class A or B. Class A - (Pulse) A pulse signal that generates noise to other circuits and is susceptible to outside noise. Class A (Pulse) signals shall be routed as a special cable separate from Class A, B, or C signals. 3. Early definition of umbilical cable connectors to mate with payload receptacle.

Table 12-4. Payload Aerospace Ground Equipment (AGE) Data, Contd

TYPE OF DATA	SCOPE OF DATA
Miscellaneous Payload AGE Data	1. Payload environmental control requirements, including shrouds. 2. Type of payload lifting equipment or handling assembly to be used. 3. Payload pneumatic and fueling requirements. 4. Payload guidance alignment requirements. 5. Payload telemetry ground checkout requirements. 6. Portable checkout equipment power requirements. 7. Any other ground service support requirements.

Table 12-5. Instrumentation Requirements

TYPE OF DATA	SCOPE OF DATA
Measurements Data	1. Quantity of payload measurements required to be transmitted by booster telemetry and type, i.e., temperature, vibration, pressure, e.g., and details concerned with relative systems and locations. 2. Impedance, operating range and full scale range of each measurement. 3. Signal conditioning characteristics, i.e., preconditioned to 0 to 5 v. payload or signal conditioning required in booster. 4. Transducers required to be furnished by Convair. 5. Minimum acceptable sampling rate or frequency response for each measurement. 6. Maximum acceptable system error for each measurement. 7. Period of flight for which data from each measurement is of interest, i.e., from liftoff to payload separation, during payload separation, etc. 8. Payload transmitted adapter area telemetry measurements including number, location, range, and type, i.e., pressure, temperatures, acoustic, vibration, strain, etc., to avoid unnecessary Atlas E/F booster duplication. 9. Booster flight data required by payload contractor and description as above. 10. Payload contractor requirements for booster telemetry processed data.

Table 12-6. Data/Documentation Exchange

TYPE DATA/DOCUMENTATION (AS SPECIFIED IN TABLES 12-1 THROUGH TABLE 12-5)	REQUIRED BY	
	PAYLOAD CONTRACTOR	CONVAIR
Structural Characteristics		L-365 Days
Separation Characteristics		L-365 Days
Payload Propulsion and Attitude Control		L-365 Days
Aerodynamic Data		L-365 Days
Mechanical Interface Data Inputs		L-365 Days
Electrical Interface Data Inputs		L-365 Days
Measurements Data		L-300 Days
AGE Cabinets Data Inputs		L-210 Days
Payload Electrical Conductor Data		L-210 Days
Miscellaneous Payload AGE Data		L-210 Days
* and ** Interface Specification	L-180	L-180 Days
Flight Sequence of Events	L-180	L-180 Days
*Input to Joint Operation Plan		L-180 Days
Mass Properties (Trajectory Targeting Input Report)		Preliminary data as soon as possible; Firm data L-155 Days
Listing of Post Flight Data Required from Convair, in Addition to Preliminary Post Flight Report		L-120 Days
Input to Pad Safety Report		L-90 Days
Payload Launch Site Schedule		L-90 Days
**Payload. Launch Site Checkout, Handling and Countdown Procedures		L-60 Days

L = First launch date.

* Prepared by Convair.

** Mutually agreed to between Convair and payload contractor and approved by SAMSO